# SCIENTIFIC AMERICAN SUPPLEMENT


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The Pugmills and Filter Presses.

Mechanical Kneaders Working the Crude Mass.

THE MANUFACTURE AND TESTING OF PORCELAIN ELECTRICAL INSULATORS.—[See page 72.]

# The Electric Smelting of Zinc Ore*

By W. R. Ingalls

THE electric smelting of zinc ore during recent years has engaged much attention. It is not a new idea. The Cowles brothers tried it in 1885, which was the first attempt (so far as I am aware), and since then numerous experimenters have undertaken it. It is not my intention in this paper to trace their work, or go further into the history of the subject. It is sufficient for my present purpose to mention that C. P. G. De Laval was the first to erect an electric zinc-smelting furnace on a commercial scale, this having been done in Scandinavia in 1901. Works were later erected at Sarpsborg, in Norway, and at Trollhättan, in Sweden. I do not know precisely the dates of their erection, but they were in operation as early as 1905. It was attempted at first to smelt ore, but for a long time this was not commercially successful, the product being chiefly zinc powder, which had to be subjected to resmelting, giving an impure spelter, which had to be refined. The works were continued in operation in a more or less irregular way and spelter from them came on the market, but this was the product of smelting dross, scrap and other secondary products rather than ore. Some progress in ore smelting was made, however, and during 1911 a considerable quantity of ore was smelted by a method, to which I shall refer subsequently.

There is much misconception respecting both the ordinary art of zinc smelting, and the possibilities of electric smelting. In the first place, the ordinary art of zinc smelting is not extraordinarily backward, in spite of the small retorts to which we are limited; and although we are attracted by the possibility of conducting the distillation in a relatively large apparatus, electrically heated, I am not yet by any means prepared to say that electric smelting will offer any advantage over existing methods, even if the difficulties that are now in view can be overcome. In the second place, electric smelting is not to be expected to accomplish the establishment of any radically new metallurgical principle. If there be any dreams of an electric furnace analogous to the blast furnace, in which run-of-mine ore may be charged roughly and from which spelter, lead and perhaps also copper matte, may be obtained concurrently, I fear that there will be no realization of them.

### CARBON REDUCTION AND IRON DECOMPOSITION.

Whatever be done in electric smelting is generally expected to be based on the reduction of zinc oxide (or its compounds) by carbon (and carbon monoxide); but the decomposition of zinc sulphide by iron has also been contemplated. The former is the basis of ordinary practice. The latter has been exploited in the electric smelting of Coté-Pierron and of Imbert-Thomson-Fitzgerald. While the decomposition of zinc sulphide by iron has not found application in ordinary furnace work, it has been repeatedly suggested. Indeed, the Imbert process was originally such a suggestion, the use of an electric furnace for its execution being an afterthought. The Coté-Pierron process was tried experimentally at Lyon, France, in 1906, and in 1907 at Arudy, in the Basses-Pyrenees, and was ephemerally the subject of many articles in the technical press, but lately it has not been mentioned, and I am inclined to think that the results were not satisfactory. The Imbert-Thomson-Fitzgerald furnace has been in trial at Hohenlohehütte, Upper Silesia, during the last two years. No authoritative reports of the results recently obtained there have been made public. The imperfect news that seeps through professional and commercial channels is conflicting. I shall not in this paper discuss either the Coté-Pierron or the Imbert-Thomson-Fitzgerald proposals, but shall confine myself to a consideration of the reduction of zinc oxide by carbon. In this discussion I shall draw upon general metallurgical experience, upon the information obtained in experimental electric zinc-smelting at McGill University, and upon the authentic reports of work that has been done elsewhere.

The reduction of zinc oxide is an endothermic process, i. e., heat must be supplied to it. This may be done either by the external heating of the retort containing the charge by the combustion of coal, or by internal heating by means of the electric current. The theoretical advantage of the latter rests in the possibility of developing the heat in the midst of the charge, i. e., in the heart of the place where the work is to be done, a condition that does not exist in ordinary external heating. The electric furnace may be of two types, namely, the arc furnace and the resistance furnace. To draw a familiar analogy, the arc furnace is exemplified by the ordinary arc lamp used for illumination; the resistance furnace by the ordinary incandescent lamp. Another type of furnace, namely, the induction furnace, will not here be taken into consideration.

### TYPES OF FURNACES.

The original De Laval furnace was a simple arc furnace, in which the heat of an electric arc, formed between electrodes projecting horizontally into the furnace, acted upon the charge of ore lying under it. Among the various types of resistance furnace we may have that in which the current passes through a resistor of carbon (as in the Imbert-Thomson-Fitzgerald), or that in which the electrodes dip into the charge to be smelted, or into a bath of slag which serves as the resistor. It will be unnecessary for the present consideration to go any further into the subject of the types and design of furnaces. It is the fundamental metallurgical principles upon which it is still most important to center attention. In the present status of the art of electric zinc-ore smelting, the functions of the electrician are subordinate to those of the metallurgist.

In the earliest attempts to smelt zinc ore electrically, the conception was of an apparatus similar to an ordinary retort, but electrically heated. In some of our early experiments at McGill University, we used furnaces of analogous character. The rate of reduction in these furnaces was about on a parity with the rate in the ordinary retort, temperatures being equal, which was, of course, what was to be expected. These experiments, made primarily for another purpose, confirmed the idea that if electric smelting were to offer any advantage, it must be conducted continuously. Here is introduced a departure from the conditions of ordinary smelting, which is an intermittent operation, conducted in two stages, the first comprising the expulsion of aqueous vapor, and the decomposition of hydro-carbons and carbonates; and the second being that of the reduction of the metallic oxides. If zinc smelting is to be done continuously, it seems that the operation must be confined to the second stage, which implies that the things that ordinarily happen in the first stage must be caused to take place by a previous pre-heating. With such a pre-heating the actions in the furnace become essentially the same, but there are certain important differences.

### DIFFERENCES FROM ORDINARY PRACTICE.

One of these differences pertains to the carbonaceous reduction material that is mixed with the ore. It has been shown by Boudouard that the permissible limit of carbon dioxide in the gas of the zinc retort is very low; varying with the temperature, but still very low at the very high temperature of 1500 deg. Cent., a temperature that is not attained in practice. When the permissible limit is exceeded, carbon dioxide acts oxidizingly upon the zinc, and coating the condensing globules of the latter prevents coalescence and forms powder.

The gas issuing from the zinc retort of practice is within the permissible limit of carbon dioxide, or nearly within it, and the zinc is condensed chiefly as molten metal. Conversely, all attempts to smelt zinc ore in the blast furnace have resulted only in the production of powder because of inability to control the percentage of carbon dioxide. Small quantities of molten zinc have been occasionally found in the blast furnace, undoubtedly owing to the accidental occurrence of favorable conditions.

The uniformly favorable conditions of the ordinary zinc retort are due to its small size, its confined character, and the presence of an immense excess of carbon in the charge. Carbon dioxide, resulting from the reduction of zinc oxide, and from other reactions, is immediately exposed to the great surplus of finely divided, intimately admixed, incandescent carbon, and is reduced by it to monoxide.

Continuous charging implies discharging of the residue without interrupting the smelting operation. This, in turn, implies the discharging of the residue as a slag that will run. Both conditions imply the absence of any great excess of carbon, which cannot be slagged and cannot be permitted to accumulate in the furnace. In this important particular, the internally heated, continuously operated retort or furnace differs materially from the externally heated, intermittently operated retort.

### CARBON DIOXIDE.

In our experimental work at McGill University, we have commonly found high percentages of carbon dioxide in the gases from the furnace, much higher than exist in the gases from the ordinary retort. Besides this difference we have observed the presence of considerable quantities of carbon and ore-dust in the condensers, indicating another variation from the conditions of the ordinary retort. In the continuous feeding of the charge into the electric furnace, there is naturally stirred up some dust which may be, and probably is, carried out into the condenser by the relatively strong outrush of gas and vapor; the latter may indeed entrain some dust from the surface of the charge in the furnace. There may be some other physical disturbances.

The effect of the carbon dioxide in the gas has been recognized by Coté-Pierron, by Johnson, and by other investigators who have caused the gas and vapor from the retort to pass through a column of incandescent carbon, the purpose of which is to act as a secondary reducer. This is believed to be, at least, ameliorative.

Except for the metallurgical differences that have been previously pointed out herein, the reactions and condition in the internally heated retort are essentially the same, providing that the charge introduced into the former be preheated to a degree corresponding to the preheating that takes place in the first stage of the intermittent process. The gradually introduced charge, with its interstitial air, should not involve any new conditions, except those previously noted, inasmuch as the gas inside of the furnace displaces the interstitial air before the charge enters into the smelting chamber. The reduction of lead and iron, developing carbon dioxide, and the multiplicity of complex side-reactions, take place in one kind of retort as well as in the other.

There is no positive evidence that the electric current passing through a furnace plays any metallurgical part other than thermic. Harbord reports no observed difference between the actions of the arc furnaces at Sarpsborg and the resistance furnaces at Trollhättan, except in the efficiency of the energy supplied. At McGill University we observed arcing in the furnace when a resistor of fragments of carbon was used; and this arcing was followed by disturbance in the furnace that we have been unable to explain; but there was no such occurrence in a furnace with a continuous resistor of carbon, in which furnace the reduction of zinc oxide appeared to take place regularly and normally. This particular furnace was provided with a peep hole (closed by mica), through which the process of distillation could be observed. The resistor was vertical in position, the charge surrounding it. The distillation proceeded most actively around the resistor, the heating element, the charge coning down toward this as the zinc was expelled, and the interior of the furnace maintaining an even incandescence.

### SPEED OF REDUCTION.

Our attempts at McGill University to reduce zinc oxide in an intermittently charged, electrically heated retort, resulted in so slow a reduction that the prospect of advantage seemed to be insignificant. I refer to a retort in which the charge was introduced in the usual manner at the beginning of the operation, the residue to be discharged as an unfused ash. There was, of course, a possibility of converting this from an intermittent to a continuous operation, but, as I have already stated, the slowness of the reduction under these conditions dispelled any such idea. When we changed to the scheme of starting the furnace with a bath of slag, continuously introducing the charge upon this bath, we found immediately that the reduction became relatively rapid. I am unable to offer an adequate explanation of the improvement in this respect. I can but state that a retort of small proportions smelts a surprisingly large quantity of charge by comparison with the retort of ordinary practice at an equivalent temperature. With a furnace of which the laboratory was a plumbago crucible 12 inches in diameter, we have been able to smelt 10 pounds of ore per hour. With a furnace 18 by 18 inches in horizontal section, we smelted 737 pounds in 23 hours. We have learned consequently that the claims of extraordinary capacity of electric zinc smelting furnaces of comparatively small size are well founded.

Bearing in mind the main difference between the conditions of ordinary and electric zinc smelting, we may pass on to a consideration of similarities. There is no reason to believe that the reduction of the metallic oxides, the reactions between metals, oxides, sulphides and sulphates, the scorification of oxides, and, in short, the multiplicity of complex reactions that we believe to take place in the externally heated retort, will be any different in the internally heated, the nature of the charge and the temperature remaining the same.

### THE MATTER OF TEMPERATURES.

With respect to the matter of temperature, that of the electric furnace may be anything that it is pleased to make it, within the limitations of the material whereof the furnace may be constructed. In the ordinary practice of zinc smelting, the tendency in Europe during

*A paper read at the meeting of the Canadian Mining Institute, at Toronto, March 8th, 1912, and published in the *Engineering and Mining Journal*.

recent years has been to drive the furnace harder and harder. A furnace temperature of 1400 deg. Cent. was once thought to be high, but now 1500 deg. Cent. and upward is reported. Such high temperatures imply, of course, the necessity for much more substantial furnace construction and a high class of refractory material. Naturally the average life of the retorts is reduced. The actual smelting temperature, i. e., the temperature inside of the retorts, is about 100 to 200 degrees less than the furnace temperature. In this particular the electric furnace has the advantage that the full temperature of the furnace is realized in just the place where the smelting is to be done.

The amount of zinc remaining in the residuum, whether the latter be an ash (loose or clinkered) or a slag, depends primarily upon the temperature of the smelting and the fluxing of the ore. Conditions favorable to low zinc retention are high temperature and highly calcareous slag. It is possible to discharge from the electric furnace a slag containing less than 1 per cent of zinc. We have made such slags at McGill University, and other experimenters also have done so. The ability to do that does not, however, imply either commercial feasibility or advisability. It may be impossible to maintain a furnace in continuous operation under the conditions necessitated by the production of such a slag. This matter has not yet been worked out. The slag made at Trollhättan, during Mr. Harbord's test, was high in zinc. We do not as yet know much respecting the shape that the smelting chamber of an electric furnace will naturally assume, the formation of refractory accretions on the walls, the deposition of sows of metallic iron (that doubtless will be produced in the same way as in the ordinary retort), and the difficulties that are likely to occur in continuous operation from these things.

### SMELTING AT TROLLHÄTTAN.

The operations at Trollhättan and at Sarpsborg were the subject of a report by F. W. Harbord, in 1911, which is the only recent source of technical information respecting them. Mr. Harbord's report was made privately for commercial purposes and did not go fully into the metallurgy of his subject. Mr. Harbord conducted a test at Trollhättan, during which 537 metric tons of ore were smelted, the test extending through 27½ days. This is the longest continuous run on a large scale that has been reported. The ore was essentially a zinc-lead ore, rather than a zinc ore, and was high in silver, containing 36 per cent zinc, 24 per cent lead and 30 ounces silver per ton. In making deductions from the experience in smelting this ore, we must hesitate in applying them too freely to the cases of what are more distinctly zinc ores. Mr. Harbord extracted 64 per cent of zinc, 74 per cent of lead and 46 per cent of the silver as metals, which percentages would be slightly increased by further treatment of certain incidental products, but even so the metal recovery would still be relatively low.

A summary of Mr. Harbord's report is to be found in the *Engineering and Mining Journal* of February 10th, 1912. Briefly, the furnaces were of the resistance type, having one large vertical electrode passing through the roof, the other electrode being a carbon block bedded in the bottom of the furnace. Each furnace smelted about 2,800 kilogrammes of ore per 24 hours. The product was partly metal and partly blue powder and oxide, containing about 54 per cent of zinc and 20 per cent of lead. This powder is mixed with fresh ore and recharged, when a larger percentage of the metal volatilized is recovered as metal. The first operation of smelting ore alone is to be regarded mainly as a concentrating process for the production of a rich oxide. The regular charge was 100 kilogrammes of roasted ore, 200 kilogrammes of powder, 25 kilogrammes of coke dust and 5 kilogrammes of lime. Thus for every ton of ore smelted, two tons of powder had to be resmelted; indeed, rather more than that, there having been an accumulation of powder during the run.

### RECOVERY OF LEAD.

In the ordinary retort the lead content of the ore is reduced and is partly volatilized, condensing with the zinc, which it contaminates; and partly remains as metal in the residuum, from which it is recovered by smelting the latter, or by jigging and smelting the concentrate. The percentage of lead volatilized increases with the temperature. In the electric furnace lead behaves in the same way, but in fusing the residuum into a slag, the lead is given an opportunity to separate and thus may be tapped separately, which in so far is an advantage. On the other hand, the desirability or necessity of smelting at a high temperature leads to the collection of a leady spelter, which must undergo a subsequent refining, and the experience at Trollhättan has indicated difficulties in the furnace construction because of the lead.

I am not greatly attracted by the possibility of smelting for lead and zinc in a single operation, much less by aiming also to make a matte (although that may be inevitable), which adds to the difficulties, nor do I see any good reason to head in that direction. In most kinds of mixed sulphide ores the galena is easily separated to a fair degree by gravity concentration, and no loss need be experienced in such a separation, inasmuch as the galena and the blende-pyrites may be easily collected in filter bins. It should be the policy first to subject the ore to this cheap process, very likely cutting out a portion of the gangue sufficiently clean to be discarded, and pass the galena on to ordinary lead smelting, also a relatively cheap process, rather than to deliver all of the ore to the zinc-smelting process, which must inevitably be relatively dear, whether it be the ordinary one or the electrothermic.

There will be, of course, from such a treatment a percentage of lead in the blende-pyrites, and being there it will be desirable to extract it, but it is troublesome both in the roasting and in the smelting, and I conceive that the electric smelter, like the ordinary smelter, will rather have a zinc ore without lead than with it, unless it can be obtained on terms that compensate for the disadvantages. It may be accepted, however, that the electric furnace will probably obtain a higher extraction of the lead and at less cost than is possible in the ordinary method of smelting, and there are some ores wherein the galena and blende are so intimately mixed that mechanical separation is impossible, which may be treated more advantageously in the electric furnace than in any other way. I do not by any means regard this as a step in metallurgy that has yet been accomplished, but it is a possibility. The work at Trollhättan has been in this direction.

### CONDENSATION.

It has been assumed by some investigators that the difficulty of condensing the vapor resulting from the reduction of zinc oxide, lies chiefly in the condensing apparatus. It may be taken for granted that the condenser connected with an electric zinc-smelting furnace, required to deal with a relatively large quantity of vapor and operating under some conditions different from those existing in connection with the ordinary furnace, must be of dimensions and design conforming to the new conditions. It has been found possible to condense the zinc satisfactorily as spelter from the electric furnace treating zinc powder and galvanizers' dross. This has been done at Trollhättan, where, in the refining of crude zinc, but 9.8 per cent of powder has been collected. In refining 111,794 kilogrammes of leady spelter, Mr. Harbord obtained only 11,209 kilogrammes of powder. Charles A. Weeks reported, in *Metallurgical and Chemical Engineering* of July, 1911, that in the refining of zinc dross in an electric arc furnace, during a run of 36 hours, no powder was made. In a private communication, Mr. Weeks informed me that this furnace was built and operated in the works of the General Electric Company, at Schenectady, N. Y. Accepting the foregoing evidence, which is confirmed by experience at McGill University, the reason for the production of blue powder is to be sought not in the condenser proper, but in the character of the gas and vapor delivered to the condenser; in other words, to the conditions that exist and the reactions that take place inside of the furnace itself. It has been found that when metallic zinc is simply distilled, there is no great difficulty in condensing the vapor in a liquid form, but when the vapor originates from the reduction of zinc oxide, there is difficulty.

Nearly all experimenters in ore smelting by the reduction of zinc oxide by carbon have been baffled in the attempt to condense a commercial proportion of the zinc as molten metal: We have encountered this difficulty in our experimental work at McGill University, and have not yet been able to master it. The reason why zinc vapor from the electric furnace should condense in this way has not yet been satisfactorily explained. It may pertain to the differences between the conditions of ordinary smelting and electric smelting that I have already mentioned; it may pertain also to other conditions. I shall not advance hypotheses respecting this; I shall limit myself to the mere statement of the fact.

### BLUE POWDER.

At the present time the matter of reducing and distilling the zinc and condensing the latter chiefly as spelter and blue powder is the crucial point of electric zinc-ore smelting. Until that has been accomplished, I can see no future for the process, except under special conditions of extraordinarily cheap power, peculiar kinds of ores, ect. On the basis of ore alone, the consumption of power at Trollhättan was 2,078 kilowatt-hours per 1,000 kilogrammes of ore, but for every ton of ore smelted about two tons of powder had to be resmelted. The smelting of 1,000 kilogrammes of ordinary zinc ore is reckoned to require from 900 to 1,000 calories of heat, which is equivalent to 1,047 to 1,163 kilowatt-hours of electric energy, these figures representing the cases of ordinary ores containing 25 to 50 per cent zinc. In one run at McGill University, lasting 24 hours, with a resistance furnace, 18 by 18 inches, Dr. Stansfield determined the power consumption per 2,000 pounds of ore smelted as 1,610 kilowatt-hours (about 1,771 per 1,000 kilogrammes). It has been claimed that it is possible to smelt 2,000 pounds of zinc ore with 1,000 kilowatt-hours. While it is doubtful whether such a result has yet been actually realized by anyone, the claim is plausible with respect to certain kinds of ore, although even then it is necessary to assume a high furnace efficiency. It would seem that 1,200 kilowatt-hours per 2,000 pounds of ore would be a sufficiently brilliant realization. Even such a one would put electric smelting upon a sound basis in so far as power consumption is concerned.

### COST OF SMELTING.

The art of electric zinc smelting is still too much in its infancy to permit of much more than speculation respecting the probable cost. The only data of operation on a large scale continued for a considerable period of time that are available are those of Trollhättan, where electric power, labor, etc., are obtained very cheaply. If the Trollhättan figures be applied to the conditions of power at $20 per horse-power per annum, labor at $3 per eight hours, and other elements in proportion, electric zinc smelting on the basis of the metallurgic results obtained there would be out of the question. If it becomes possible to smelt with 1,200 kilowatt-hours per ton of ore, to reduce materially the labor and electrode costs, and to extract 90 per cent of the metals, there will be some chance.

As to the probable cost of plant we are still greatly in the dark. It is hardly to be expected that the electric plant will be of any less cost than the coal fired. Comparing operating costs, there will be the same expense for administration, general charges, yard labor and roasting in each case. Heating coal will stand against electric current, say 1 to 1.5 tons against 1,200 kilowatt-hours. The relative consumption of reduction coal is uncertain. The retorts of ordinary practice will be dispensed with, but instead of them the electric smelter will have an electrode expense. The relative cost of repairs and renewals and miscellaneous supplies is uncertain; also the matter of labor. At first thought it seems that the labor on a furnace smelting 6,200 pounds of ore per day ought to be less than in connection with 80 Rhenish retorts or 150 Belgians, but the experience at Trollhättan does not yet confirm that idea, though, no doubt, improvement will be realized in this particular.

### LIMITATIONS.

In the report of the Commission to Investigate the Zinc Resources of British Columbia, published in 1906, I made the following remarks:

"The successful smelting of zinc ore in the electric furnace is a matter which depends chiefly, indeed I may say solely, upon the cost of the process. De Laval has shown that it can be done. The doing of it profitably is quite another question. This is dependent chiefly upon the cost of power, the electrical efficiency of the furnace, and finally upon the purely metallurgical difficulties that pertain to the reduction of zinc oxide and the condensation of the metallic vapor.

. . . . . .

"From the present development of electrothermic smelting of zinc ore, and the calculations respecting it, the following conclusions may be drawn:

"1. Electric smelting will never displace ordinary smelting, if it be necessary to generate the power from coal.

"2. Electric smelting may be, in the future, economically conducted at places where very cheap hydro-electric power is available.

"3. Aside from the question of power, up to the present time certain peculiar and serious metallurgical difficulties in electric smelting have not been satisfactorily overcome."

During the six years that have elapsed since those words were written, much has been learned respecting their subject, but as generalizations they remain as true to-day as they were then.

The successful achievement of smelting zinc ore in an electric furnace will probably be the result of learning how to run the furnace; i. e., how to control the process, rather than of any distinct invention. I conceive that the electric zinc-ore smelting furnace will be an apparatus of general character, such as is the blast-smelting furnace for lead ore, etc. This is to say: Lead ore may be successfully smelted in many forms of furnaces of the same generic character, but with variations in their lines that are of important economic effect. Once it has been learned how to run an electric furnace for zinc smelting, I believe it will be found that the process can be conducted in many forms of furnaces conforming to the general type, wherein the principle will be the same although the economic results may differ widely.

**Vegetable Ivory.**—A new kind of vegetable ivory has been found in the fruit of a palm indigenous in the French Soudan. This may prove the source of an important industry for the French colony.—*Cosmos.*

General View of the Completed Half of the New Station at Leipzig, Saxony.

# The Largest Railway Station In Europe

## A New Railway Center at Leipzig, Germany

### By the Berlin Correspondent of the SCIENTIFIC AMERICAN

UNTIL recently Leipzig, the German city noted for its great university and as a publishing center, had very meager railway stations. This old order of things is now being changed, and when the buildings at present under construction are completed, Leipzig will boast not only of one of the largest, but also of one of the most handsome railway stations in Europe. At present about one half of the new building is completed, and even this looks most imposing and gives one a very fair idea of the appearance which the completed structure will present.

The frontage of the façade will, when completed, measure nearly 1,000 feet in length, and the transverse platform at which all of the tracks terminate is 875 feet long. There will be a daily traffic of some 400 trains, for which 26 parallel tracks are provided.

Something of the work accomplished can be gathered from the following figures:

The total amount of earth removed is 25,398,375 square feet, and no less than 1,998,035 cubic feet of masonry is contained in the bridges and retaining walls. The length of track laid is 552,500 feet, and the vault of the huge hall leading to the trains comprises 51,648 square feet of reinforced concrete.

The station is the joint property of the Saxon and Prussian railways, and the Prussian part is the one so far completed. The station is located in a most favorable spot on the Georgi Ring at the point where this makes a turn from its south-north to east-west portion. The main trend of the station buildings is from southeast to northwest. They form a great square, bounded on the city side by the green lawns of the Ring.

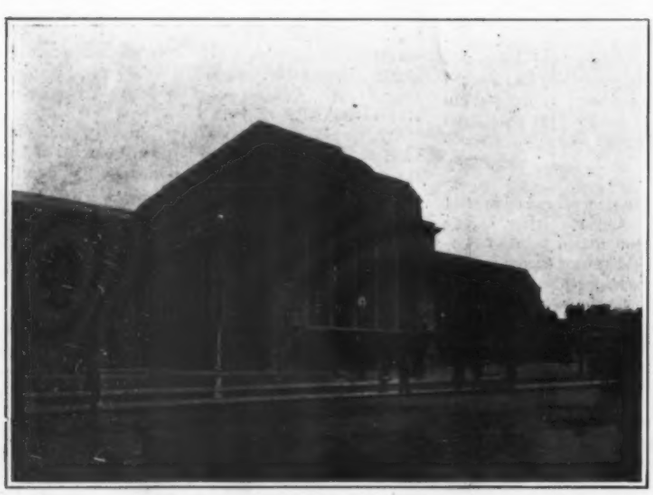
The natural approach to the station is in a diagonal direction from left to right, and the view presented to the spectator is most imposing. From the main façade there projects at the center an approximately cubical structure, as will be seen by reference to our illustration. The wing and central part carry a relatively low roof, while the roof of the projecting cube containing the entrance hall rises somewhat higher. Behind this cube extends the vault of the platform mentioned above, on which the tracks abut.

A view of the interior of this hall is seen in one of our illustrations. The illumination is most artistically arranged, the light entering partly from the vaulted roof and partly from windows in the walls. There is ample accommodation for the passengers, to avoid all crowding at the ticket offices and luggage room. The latter is arranged in a tunnel 410 feet wide and 328 feet long. Special provision is made for incoming luggage by a similar long tunnel, situated below the great plaform. The waiting rooms are designed in perfect good taste and are made most comfortable and restful in spite of the close proximity to the perpetual motion of the traffic. In addition to a large main waiting hall there are a number of smaller rooms provided. The rear portion of the main waiting room, looking toward the street, has been elevated, forming a terrace, approached by a staircase of ten to fifteen steps. This gives a very delightful view of the city.

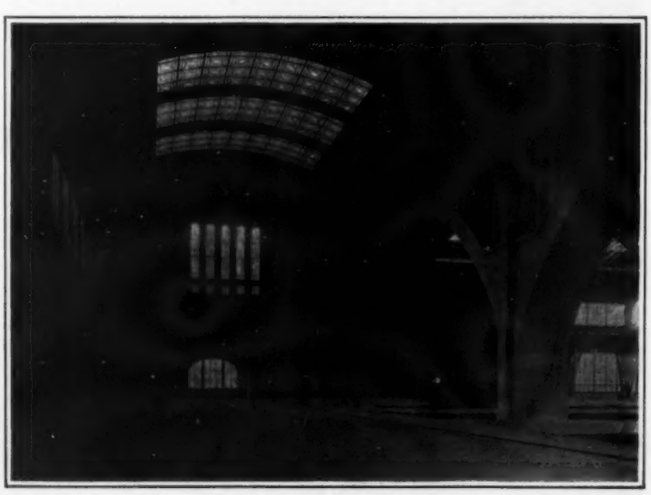
The decoration is very conservative and dignified. To the right and left of the entrance hall the Prussian coat of arms appears, but these details occupy an entirely subsidiary position, and the building relies for its artistic effect upon its fine architectural features, of which the same idea can be gained from illustrations.

It is interesting to reflect that the vast development in railway traffic which has taken place within the last eighty years or so, has brought in its train, as a by-product as it were, architectural *chefs d'oeuvre* of no mean order. The middle ages reared, for their monuments, the great cathedrals of Europe—masterpieces of architectural art inspired by man's devotion to things spiritual. It seems fitting that our practical age should be spending its art upon buildings which owe their very existence to the modern spirit of intense industrial activity. Thus it comes that to-day practically every great city of the world boasts of some giant railway terminal, imposing in its dimensions and inspiring in its artistic conception. Have we not on our own shores seen within the past few years the birth of some of the finest pieces of architecture in just this way?

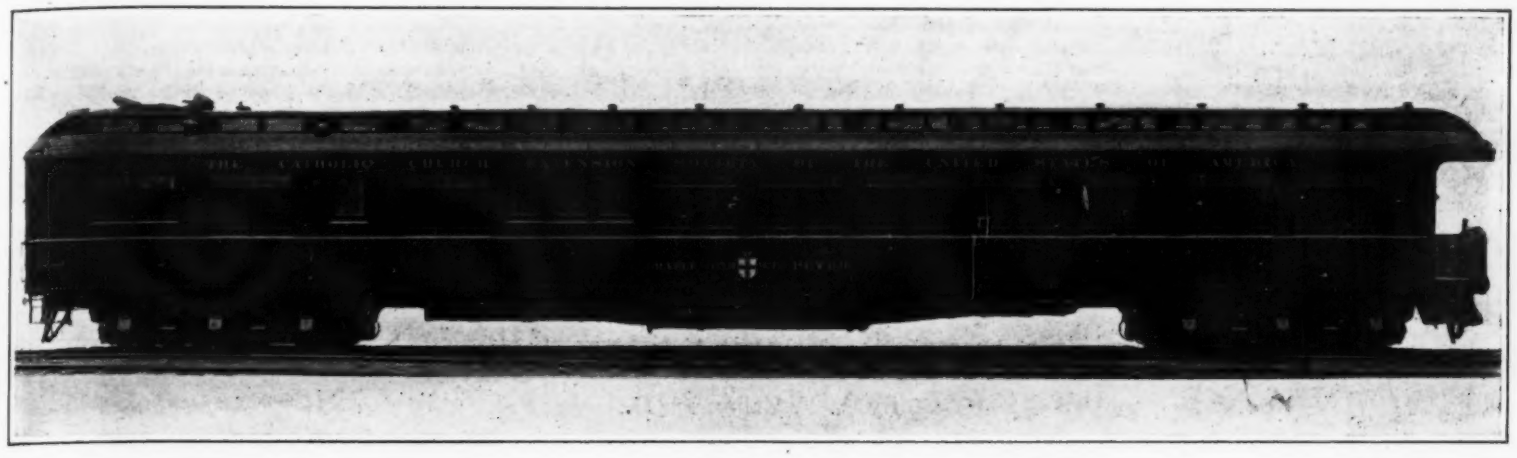
Ours is a great epoch; we who live in it can hardly obtain that perspective which would enable us rightly to judge and estimate it, and to assign to it the right place in the long procession of historic periods. We need entertain little doubt that when the lapse of time shall have furnished a vantage point from which to take a survey of this age among its forerunners and the years that follow, there will figure prominently in the picture presented to the mind, a wonderful architecture, elicited, not by man's more dreamy and meditative instincts, as in the middle ages, but by the exigencies of our strenuous "practical" times. To the gods of commerce and industry we rear those wonderful edifices that seem to meet the sky, and to the same powers are dedicated the imposing railways stations that are growing up throughout all the civilized world.



The Central Wing and Main Entrance.



Interior View of the Vestibule.



# A Chapel On Wheels

## Architectural Effects in Rolling Stock

By M. M. Hunting

THE Catholic Church Extension Society has just put into service one of the handsomest and in many respects the most unique chapel cars ever built. It is the first car of the kind ever used by a Catholic organization for church purposes, and is being sent out to neglected portions of the country such as mining communities, lumber camps and the like.

An unusually prominent feature of the interior is the similarity of furnishings and scheme of architecture to that of some of the large churches and cathedrals. This is especially noticeable in the manner in which the various emblems and symbols of the church have been incorporated in carving and design of the woodwork and decorations.

While on a less extensive scale, the equipment is as complete in essential details as a modern church edifice. The interior is finished in a carefully selected and rich appearing mahogany, the ceiling being executed in a handsome shade of dark green with simple but appropriate decorations.

The metal fixtures and hardware are of statuary bronze and a further elegant effect is given by the artistic patterns of art glass upper sashes of the windows and the ventilators.

The old Gothic type of architecture has been carried out in the design of the furnishings and gives dignified and imposing appearance to the interior which one would hardly expect in so small a structure.

On a platform elevated six inches above the main floor of the auditorium is the sanctuary and altar. These are equipped with the usual furnishings and ornaments, while trap doors in the platform conceal a storage space for literature and other supplies which the car will carry.

Between the sanctuary and the auditorium is located a communion railing, above and in conjunction with which has been built a rood screen of scroll work after the fashion of the English cathedrals. Upon this is mounted the rood or cross, the whole structure forming a sort of screen in front of the altar and making it possible to shut off this space from the auditorium by means of curtains when the car is stationary.

On the altar proper is placed the tabernacle, the door of which is elaborately decorated with carving, while above this is placed a handsome marble crucifix. The tabernacle contains the sacred documents of the church and such other materials as are regularly used in church services.

There are two small steps on either side of the tabernacle for the reception of candlesticks, urns and other ornaments, and the altar is equipped below with drawers for vestments and other supplies.

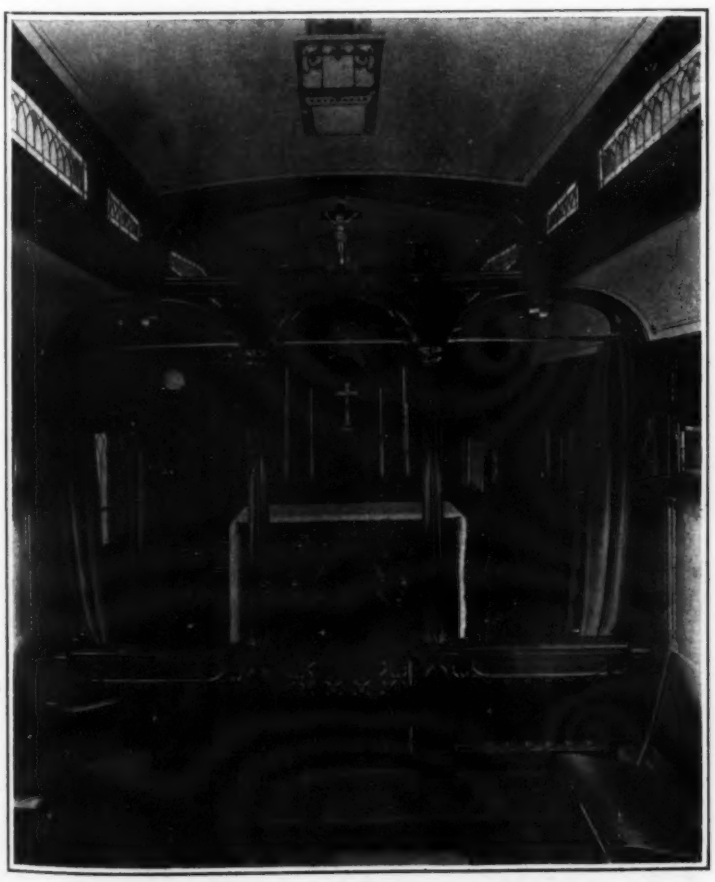
At one side of the altar on the raised platform of the sanctuary is located the confessional.

A kneeling bench extending the full width of the car is placed in front of the communion railing, and shorter steps for the same purpose are placed in front of each pew. These are arranged so that they may be raised under the pew when not in use.

On the piers between the double windows in the auditorium, and let into the side finish, are placed framed photographs of famous oil paintings illustrating the stations of the cross.

An organ designed and built especially for the car is placed near the entrance to the chapel at the observation end of the car together with a combination organ stool and music cabinet.

In the auditorium are several berths for the accommodation of a portion of the party who will accompany the car, while at the opposite end beyond the altar are located the private apartments for the superintendent of the car. These consist of a study furnished with a book-case, table, chairs, etc., a state room and shower bath. The study also serves as a dining room for all who accompany the car, and there



Raised Platform With Altar and Sanctuary.

The Study in the Superintendent's Apartment.

is a complete kitchen with a range and all the necessary cooking utensils at the front end of the car.

There are numerous lockers in different parts of the car, toilet facilities and every convenience that one would find on the best-equipped parlor car.

The exterior is painted a dark green with the name of the society appearing in gold leaf on the letter board, and the name of the car "Saint Peter" with the society's coat of arms in colors on the sides.

The car is 74 feet 10½ inches in length, and is very substantially constructed, having a built-up structural steel under-frame, steel super-structure and steel exterior.

The exterior plates are ⅛ inch steel, and the roof is of the standard shape and covered with copper.

The car is well insulated throughout to insure the greatest comfort in varying temperatures. It has a vestibule platform at one end and an observation platform at the other, six-wheel trucks and air brakes.

The interior is lighted with acetylene gas, which is generated by a plant on the car. There is, of course, the usual steam heat system.

Many other modern improvements and safety devices have been added which make the car complete in every detail and well prepared for the work to which it will be assigned.

The chapel car was built and dedicated in Dayton, Ohio, and started on its first trip June 29th. It is said to have cost twenty thousand dollars, and the society feels that the money has been well invested.

# Elements of Theoretical Aeromechanics*

## Part II Concluded.—Aerodynamics

By A. F. Zahm, Ph.D.

Concluded from SUPPLEMENT, July 27, 1912, Page 51

*Results of Higher Analysis.*—We now have touched lightly on some of the most elementary topics in the extensive, not to say formidable, science of fluid dynamics. Fortunately, they are also among the most interesting topics, and the most valuable for practical use. By the aid of analytical machinery, too elaborate for the scope of this work, other principles and conclusions may be derived, at once entertaining and important when duly applied. But it will be sufficient merely to state, without proof, some well-established theorems on the flow and resistance of a perfect fluid about various familiar geometrical forms.

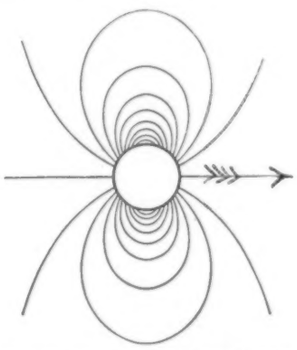


Fig. 1.—Stream-lines About a Sphere Moving Through a Frictionless, Incompressible Infinite Fluid.

In general it may be said that a frictionless incompressible fluid of infinite extent, flowing steadily and irrotationally past a body of whatever shape, encounters no resistance, and exerts no resultant pressure upon the body, but presses it equally on both front and rear. This is true not only of fair shaped objects, like the torpedo and the two-edged sword, but of angular and flat forms as well, such as the cube and normal plane. The proposition has been affirmed also of natural fluids flowing past objects of easy shape, by certain well-known writers, assuming the surface friction of such bodies to be negligible. But the proposition is untrue in theory, and disproved by experiment. Theory shows that no viscous fluid can flow without resistance past any geometric solid, even though perfectly smooth; and experiment shows that all such bodies offer both head resistance and skin-friction. It is evident without computation that viscous fluids must encounter some resistance in flowing about solids, however smooth, because the stream-lines crowd each other, and adjacent fluid filaments run at different speeds, thus generating internal friction and consuming energy, which can be ascribed only to the resultant pressure of the immersed object. It may be inferred, however, that when the motion is so extremely slow that the frictional effect is negligible the viscous fluid behaves sensibly like a perfect one.

Another general theorem asserts that when the above hypothecated frictionless fluid moves past a solid with accelerated speed, or when the solid moves with accelerated speed through the quiescent fluid, there is always a resistance, and this is directly proportional to the acceleration. Commonly the fluid resistance, in accelerated motion, can be expressed by merely endowing the moving object with a certain additional mass, and writing its impulsive resistance equal to the product of this additional mass multiplied by its acceleration; entirely ignoring the pressure of the fluid. For a sphere the additive mass is half that of the displaced fluid; for a circular disk moving normally it is slightly over five eighths of the fluid mass displaced by a sphere of equal diameter; for a circular cylinder moving transversely it is exactly the mass of the fluid displaced; for an elliptic cylinder it is the same as for a circular one whose diameter equals the major or minor axis, which ever is placed transversely to the line of motion. In each case the additive mass of the moving object multiplied by the acceleration gives the fluid resistance; but, of course, to find the whole resistance to acceleration, due to the inertia of both the body and the medium, the mass of the body itself must be combined with the fictitious additive mass, which latter represents only the equivalent of fluid resistance. For example, the resistance of a sphere is $(m+m')\,j$, in which $m$ is the mass of the sphere, $m'$ is half the mass of the fluid displaced, and $j$ is the acceleration of the moving sphere.

Enough has been said to show that the equivalent inertia of a solid accelerating through a fluid is very material, if its density and that of the fluid are at all comparable. Due account of this fact, therefore, should be taken, in studying the resistance of natural fluids in unsteady motion, or of objects accelerating through such fluids. Unfortunately, this is not always done, even by fastidious experimentalists.

The stream-lines of the hypothetical fluid under consideration, as it flows steadily past opposing objects, have been determined mathematically for various geometrical forms, and graphically outlined for a number of interesting cases. Figs. 1, 2, and 3 represent, respectively, the stream-lines round a sphere, a circular disk, and a circular cylinder of infinite length, each moving through the fluid. The stream-lines for limpid natural fluids are of similar character, except in the immediate rear of the moving objects, where a turbulent wake occurs, and at sharp turns and angles which produce eddies on the sides and rear. Also it may be noted that for elastic fluids the maximum deflection of the outer stream-lines cannot occur opposite the widest section of the obstacle, but occurs farther to the rear, some time being required to carry the impulse outward. This will be seen in the stream-line figures obtained experimentally.

The theoretical stream-lines for a sphere, a circular cylinder, and an inclined plane, each held stationary in the medium, are shown in Figs. 4, 5, and 6. In both front and rear of each there is a median stream-line abutting squarely upon it at the point of greatest pressure, and separating the main parts of the current. For the inclined plane the points of abutment are not, in general, at the centers of pressure, but nearer the edges than these are. Needless to say that the resultant pressure is in front of the center of surface, so that an inclined plane tends to set itself squarely to the current, if pivoted at the center of surface.

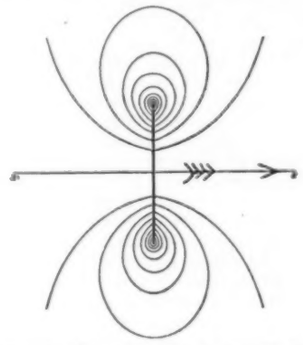


Fig. 2.—Stream-lines About a Circular Disk Moving Through a Frictionless, Incompressible Infinite Fluid.

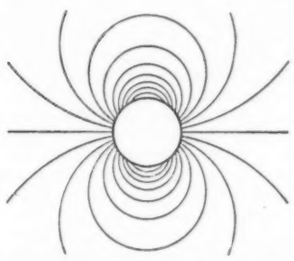


Fig. 3.—Stream-lines About a Long Circular Cylinder Moving Transversely Through a Frictionless, Incompressible Infinite Fluid.

### DYNAMICS OF VISCOUS FLUIDS.

The general equations of motion of a viscous fluid have the same form as those representing the motion of a frictionless fluid, except for the addition of terms involving the co-efficient of viscosity. This co-efficient represents a physical quantity which has been accurately determined for many fluids by exact measurement. It is sometimes also termed the co-efficient of internal friction. When the velocity varies from stratum to stratum in a viscous fluid, the unit shearing stress on the face of any thin lamina taken parallel to the flow, varies directly as the fluid velocity gradient taken squarely across the lamina. The ratio of this stress to the gradient is called the co-efficient of viscosity. In other words, the shearing stress in a viscous fluid is proportional to the rate of shearing strain, and the factor of proportionality is called the co-efficient of viscosity.

In a perfect fluid moving without compression no

* Abstracted from the author's treatise on aeromechanics, reproduced from the *Journal of the Franklin Institute.*

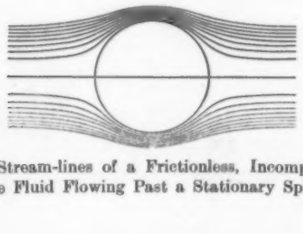


Fig. 4.—Stream-lines of a Frictionless, Incompressible Infinite Fluid Flowing Past a Stationary Sphere.

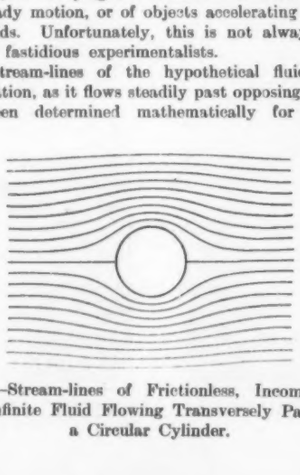


Fig. 5.—Stream-lines of Frictionless, Incompressible Infinite Fluid Flowing Transversely Past a Circular Cylinder.

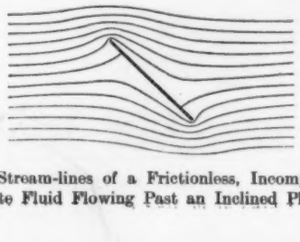


Fig. 6.—Stream-lines of a Frictionless, Incompressible Infinite Fluid Flowing Past an Inclined Plane.

heat is generated, however its particles may suffer change of shape. But in a viscous fluid all changes of shape of the particles, as well as all compression, require the expenditure of work, and cause the development of heat within the fluid. All such changes of shape, therefore, result in the dissipation of energy. This means that the only condition under which a viscous fluid of constant bulk can move without dissipation of energy by internal friction is that there must be nowhere any extension or contraction of its linear elements. In other words, the motion must consist of a translation and a rotation of the mass as a whole, as in the case of a rigid body.[1]

In all cases of motion, therefore, of a solid through a natural fluid, whether at constant or at variable velocity, resistance is encountered, and energy must be expended in propulsion. This is true even of an infinitely thin material plane moving edgewise, for if the fluid slips along the laminar surface it offers sliding resistance, while if it adheres to the lamina it still offers resistance due to the internal friction between the adherent layer of fluid and the stratum adjacent, the whole neighboring part of the fluid suffering lamellar strain. Both cases of motion are of interest in aerodynamics, that in which the surface slip is inappreciable, and that in which it is pronounced.[2] The first condition is usually assumed in the analytical treatment of problems in viscous fluid dynamics. Of the many problems so treated only a few are of sufficient interest to be noticed here; and only the results of their solution can be expressed in elementary form. These may be briefly presented.

[1] Lamb, "Hydrodynamics," 1906, p. 541.

[2] Some writers have questioned whether slipping occurs between a solid and fluid in relative motion; but the fact that fine snow-flakes slide rapidly over smooth ice, due to the wind, seems to manifest slipping between the air and ice. Mary's wind-tunnel experiments furnish like evidence of slipping between air and solid surfaces.

The resistance of a sphere translated at constant speed through an infinite incompressible viscous fluid has been determined for the case in which its radius and speed are so small as to make the inertia effect negligible by comparison with the viscous effect. The expression found for the resistance takes the simple form:[3]

$$R = C\pi\mu r U$$

in which $r$ is the radius of the sphere, $U$ is the velocity, and $\mu$ is the co-efficient of viscosity. The stream-lines caused by the translation of the sphere are as shown

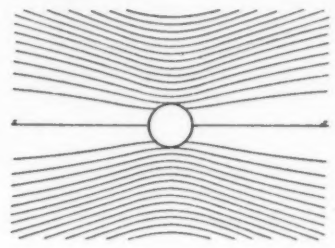


Fig. 7.

in Fig. 7. The equation is applicable to the case of fine sand falling in water, or to fine mist or dust falling in air, but is not applicable to bullets or larger bodies, moving at a considerable rate of speed.

The rate of flow, $Q$, of a liquid through a tube, with no slipping at the wall, is given by the expression

$$Q = cr^4(p_1 - p_2)/l$$

in which $r$ is the radius of the pipe, $p_1 - p_2$ is the fall of pressure in the length $l$, and $c$ is a constant of the value $\pi/8\mu$. Thus, the rate of flow through a tube varies as the fourth power of its diameter, as the pressure difference at its two ends, and inversely as its length. Since every quantity in this equation can be measured, except $c$, the expression may be used to find $c$, and thence the co-efficient of viscosity. The equation exactly expresses the laws found experimentally by Poiseuille in his researches on the flow of water through capillary tubes.

[3] Lamb, *"Hydrodynamics,"* 1906 Ed., p. 553.

For the case of accelerated motion of a viscous fluid the mass times the acceleration of a small element of a stratum in laminar flow may be equated to the resultant shearing stress on its faces, if the pressure gradient in the direction of motion be ignored. In this way the tangential resistance of a solid cylinder rotating in an extended stagnant viscous fluid which adheres to it has been computed by Dr. Carlo del Lungo.[4] He finds for the unit tangential surface stress $R$, the value

$$R = u\sqrt{\frac{\mu\delta}{\pi t}}$$

in which $u$ is the velocity of the solid, x is the density of the fluid, and $t$ is the time estimated from the beginning of the rotation. Applying this result to compute the frictional resistance of a thin material plane of length $l$, width $a$, and area $S = al$, Lungo obtained for the total friction $F$, on one side of the plane

$$F = \tfrac{1}{2}S\sqrt{\frac{\mu\delta u^3}{\pi l}}$$

which can be written more simply in the form

$$F = cu^{1.5}l^{0.5}$$

From this he concludes that the skin-friction of fair-shaped bodies should vary approximately as the 3/2 power of the speed and the 1/2 power of the length. A like equation obtained by a different mathematical process was published later by F. W. Lanchester.[5]

[4] *Sulla Resistenza D'Attrito fra Solidi e Luiquidi, Revista Tecnica, Anno V, Fasciolo 6.*

[5] *"Aerodynamics,"* London, 1908.

# Making the Blind Hear Light

## Fournier d'Albe's Optophone

THE "Optophone" is the name given to a new instrument shown at the recent Optical Convention. It is the invention of Mr. Fournier d'Albe, of Birmingham University, England, and is designed to enable totally blind persons to recognize, locate, and even measure light by means of the ear.

It is based upon the well-known property of selenium of changing its resistance under the action of light. The principle on which the optophone is constructed is the following: A current from a small battery is sent through a network of four conductors known as a "Wheatstone bridge." Two of these conductors are wire resistances of a few hundred ohms each, the third is a selenium "cell" (now more appropriately termed a "selenium bridge"), and the fourth is an adjustable resistance, made of graphite deposited on ground-glass or unglazed porcelain. When the first two resistances are in the same ratio as the last two, then no current will flow across the network. But a current will flow as soon as one of the resistances changes, as does that of selenium under the action of light. It is this current, made audible in a telephone, which is utilized in the optophone.

The instrument, as exhibited, consists of two parts. One of them is a pair of high-resistance telephones, as used for wireless telegraphy. The other is a long box, measuring 18 by 4 by 6 inches, which contains the selenium bridge, the battery, the wire resistances, two adjustable carbon resistances, and a clockwork interrupter. The last is there for the purpose of making the telephone current intermittent, as a continuous current is inaudible in the telephone.

The method of using the optophone is as follows: The telephones are attached to the head, and the optophone box is carried in the right hand, connected by flexible wires with the telephones. On turning on the current and starting the clockwork, a ticking or rasping sound is heard in the telephones. This can be reduced to silence by adjusting the sliding carbon resistance, and by an auxiliary resistance giving a fine adjustment. That silence will continue so long as the light shining into the box remains of the same intensity; but a very slight change of illumination, either a brightening or darkening, suffices to restore the sound in the telephone, and the loudness of the sound produced measures the extent of the brightening or darkening of the light.

In practice, it is found best to adjust the resistances so that the brightest light available produces silence, and then the various shades of darkness produce sounds of corresponding intensity.

A striking experiment with the optophone is to point the box (it might be called a "camera") to a window, and adjust to silence. Then the hand, or other opaque object, passed across the open end, between the box and the window, indicates its passage by a sound in the telephone. You can hear it "rasping" across the

A Blind Man Listening to the Flame of a Match.

The inventor, Mr. Fournier d'Albe, on the extreme left.

line of sight. Even a quick passage produces an audible sound. In sunlight or bright electric light the effect is very remarkable. Conversely, if the instrument is silenced for darkness, a light produces a sound whose loudness measures the intensity of the light. Moonlight is very audible, and the sun roars.

A very good idea of the extent to which the instrument helps the totally blind may be arrived at as follows: Make a long box of rectangular section, 4 by 6 inches, and 18 inches long, open at both ends. Insert a plate of ground-glass, 4 by 6 inches, in the center of the box, at right angles to the length, and a similar plate within 1 inch of one end. Put this end against the eyes, excluding all light except that which shines dimly through the ground-glass. You are now in the position of a totally-blind person armed with an optophone. You can locate windows and lights, and can, with a little practice, make your way among your surroundings by taking note of light differences of shade. You are still, of course, enormously handicapped in comparison with persons in full possession of their sight; but a first bridge has been thrown between the world of darkness in which the black-blind live and the world of light.

The instrument is light and portable, and requires very little current, a single pocket "refill" sufficing for days of working.

As it stands, the optophone is very little use to those of the blind who suffer merely from the turbidity of the lens or humors of the eye. For they perceive, as a rule, as much light as is indicated by the optophone. But the instrument is only in its infancy, and can be immensely improved. Thus, instead of a single selenium bridge, a mosaic of bridges might be used, and the sounds from the various bridges might be distinguished by associating them with notes of various pitches. The world of light could thus be made to "sing" of its glories to the blind. To rival the human eye, even only as regards the central spot of distinct vision, the mosaic would have to consist of at least 10,000 separate elements, and that appears at present almost hopeless. But there is no reason why the sense of touch, rather than the ear, should not be brought into play, especially as the blind already rely largely upon the sense of hearing to make up for the loss of sight. In that case, certain areas of the skin, with a totality of 10,000 nerve-endings, might be trained to take up the functions of sight. The retina is, after all, only specialized skin. In monocellular organisms, the sense of sight is evenly diffused over the whole surface. A radical solution of the blind problem would have to be based on the first principles of sensation. If the skin elements specialized for sight refuse to function, other skin elements must be trained to do their duties. In some such way as that the problem may be completely solved eventually.

But for the present, the optophone gives a first aid to the totally blind, bridging the gulf between them and the light, and opening up a new world to those who have never seen.—*The English Mechanic and World of Science.*

**Waterproof Coating for Paper.**—One hundred parts rosin, 40 parts tallow, and 40 parts paraffine, melted together in a kettle, the paper to be immersed in the mixture.

The Hall in Which the Porcelain Articles Are Shaped.

# The Manufacture of Porcelain Insulators

## Testing the Products for Leakage at High Tension

By Dr. Alfred Gradenwitz

PORCELAIN consists mainly of a mixture of kaolin, quartz, and felspar, in proportions variable to a high extent in accordance with the purpose it is intended for. For electrical applications hard porcelain, consisting of a kaolin core immersed in felspar and quartz paste, is used exclusively. This composition, which is burnt at a very high temperature, gives a very high mechanical and electrical resistance, as required in electrical insulators.

After being crushed and ground, the quartz and felspar are thrown into troughs filled with water and fitted with mechanically operated stirring devices, and are there mixed with kaolin previously freed from impurities. The liquid paste thus formed passes through fine copper wire sieves, whereby it is freed from coarse particles, and thence under electro-magnets, which arrest any particles of iron oxid, and finally into tanks, from which it is pumped to filter-presses submitting the paste to pressures of 8 to 10 atmospheres and thus eliminating the excess of water.

The paste is taken out of the presses in the form of plastic cakes, which are conveyed to kneading machines in which rotating cylinders work the paste so as to expel air bubbles and form homogeneous blocks. Thus prepared, the paste is ready for the manufacture of porcelain insulators. The blocks are first cut into lumps of convenient size, and are submitted to a preliminary shaping on a vertical lathe on which the inner hollow of the insulator is turned out.

After this preliminary shaping the lumps are dried by heat and are handed over to workmen whose task is to shape the outer surface of the insulator. For this purpose horizontal lathes are used. At the same time the screw thread is put on.

In the case of insulators of smaller resistance, the shaping is effected by a cheaper casting process. For this purpose a pulverized paste slightly moistened with oil is compressed in steel matrices of a shape corresponding to that of the insulator.

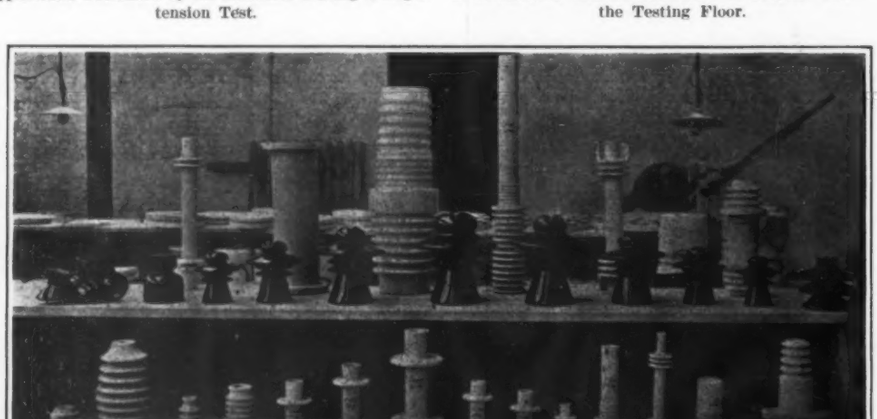
After drying, the insulators thus shaped are burnt at a high temperature in special furnaces and are enameled in incandescent furnaces. This process of manufacture warrants a high mechanical strength and electrical resistance.

Insulators destined for use in power transmission overhead lines have to fulfill many special conditions (mechanical, electrical, etc.). In the first place they must be of a high mechanical strength, which not only depends on the composition of the porcelain used, but on the external shape of the insulator. As porcelain is remark-

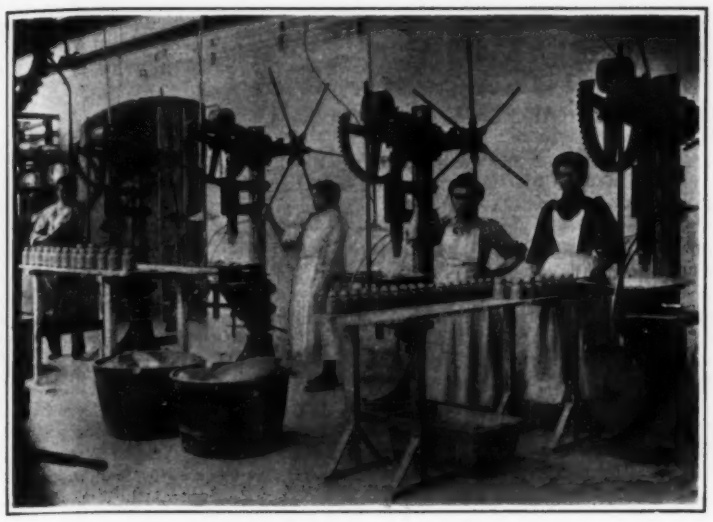
Appearance Presented by an Insulator During a High-tension Test.

A 50-kilowatt Transformer—250 to 250,000 Volts—on the Testing Floor.

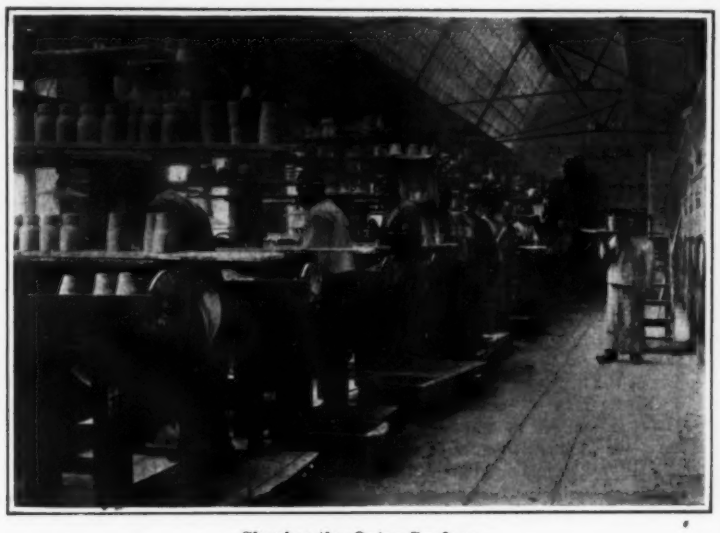
Testing a Wetted Insulator at 130,000 Volts.



Some Samples of Insulators and Other Porcelain Articles for Electrical Purposes.



Mechanical Molding of Insulators



Shaping the Outer Surface.

ably resistant to compression, while comparatively ruptured by tension, insulators should be given a shape such as to eliminate as far as possible interior or exterior strain; they should likewise be resistant to the breaking effect of accidental external causes, such as the impact of falling branches, stones, etc.

As regards its electrical properties, an insulator should have no appreciable internal or surface conductivity. It should be of considerable disruptive strength and of a shape such as to be protected against any discharges occurring between its edges and the metallic support. Moreover, even for high tension work, insulators should be of as small weight and dimensions as compatible with other requirements, and should at the same time be readily fitted and cleaned. Finally, they should be sufficiently resistant to the action of acids, atmospheric discharges, and variations in temperatures.

In view of these varied conditions to be fulfilled, most insulator manufacturers have installed special testing and research laboratories, the equipment of which is being improved continually.

The testing laboratory of a Belgian manufacturing firm which has furnished some of the data for this article formerly comprised a 10 K. V. A. 220/110,000 volt transformer which, however, eventually proved insufficient for high tension work, especially for testing the insulators of high tension power transmission lines. The managers therefore decided on installing a new testing laboratory, the equipment of which, as supplied by the Ateliers de Construction Electriques, of Charleroi, mainly comprises a statical transformer with its tension regulator and testing troughs.

The single-phase transformer is designed for a normal permanent output of 50 K. V. A. at 250 volts primary and 250,000 volts secondary tension and 40 cycles per second. A special point was made of insuring a constant ratio of transformation with any loads, absolute safety in working, and prolonged loading without any material heating.

The magnetic circuit of the transformer consists of two cores and two yokes of soft iron sheets. The primary winding consists of two coils (one to each core), which only comprise one layer of turns wound on an insulating tubular armature. The secondary comprises a set of

A Chain of Insulators Under Test at 230,000 Volts.

series-connected coils concentric with the primary coil on each core; these coils are separated from one another by varnished card-board tubes.

The insulating tubes which separate the primary and secondary windings as well as those of the terminals have a very high dielectric constant and great mechanical strength. They consist of four parts, viz., an outside cover to which the bronze ring for fixing the terminals is attached, a fluted tube traversed by the insulating tube and two high tension tubular insulators having two superposed sleeves. By connecting the two secondary windings in series or in parallel, a tension of either 250,000 or 125,000 volts between terminals is obtained.

The tension regulator consists of a metallic rheostat inserted into the primary circuit; it comprises two sections each of which can be connected up gradually in series with each division of the other.

In order to prevent any access to the testing troughs while under tension, the laboratory has been sub-divided into three compartments. Each of the two outer compartments contains a testing trough, the transformer being installed in the middle compartment, which is partly closed in front by a switchboard comprising three white marble panels. These compartments are closed by doors carrying interrupters connected up to an automatic switch. On opening such a door, supposing the corresponding compartment to be under tension, the zero tension circuit of the switch is thus interrupted, which results in the switch being released and the bus bars being thrown out of tension.

The testing voltage is measured by means of five voltmeters connected up to the circuit which allow the voltage to be determined most accurately throughout the range of 0 to 250,000 volts. Our last illustration shows a test on a chain of insulators carried out at the testing laboratory. This chain, comprising ten links, was found to stand when dry a testing tension of 230,000 volts without any sparking.

The first and third engravings show high-tension tests made on porcelain insulators in a dry and moist condition respectively. They strikingly illustrate the abundant production of brush discharges around any parts submitted to very high tension.

## The Use of High-Pressure Gas in Works

At a recent meeting of the Institution of Gas Engineers (England), Mr. A. W. Onslow read a paper on "The Use of High-pressure Gas for Manufacturing Purposes," an abstract of which is reproduced here from *Engineering*.

The author, after considering the various methods of using high-pressure gas, concludes that the best results are to be obtained by maintaining the gas at constant pressure, and drawing in air under atmospheric conditions. If the pressure be kept steady, any heating furnace, for instance, can be calibrated, and desired conditions can be attained with certainty after allowing the lapse of a known interval of time. Working at some definite pressure, it appears that a curve of furnace temperature plotted against time will always give a substantially straight line till the point of constant temperature be reached corresponding to that pressure. If the pressure be raised, the temperature will continue to rise with the time until the new constant temperature point be reached. It should thus be possible to tabulate conditions for any heating furnace, and, instead of having to exercise a great deal of supervision over operations, a works manager should be able to give instructions as to the gas pressure to be used and the time to be allowed to elapse for the furnace to heat up before it is put to use.

Mr. Onslow is of opinion that with gas at 50 cents per 1,000 and coal at $5 per ton there is little to choose between gas and coal firing as regards cost. As regards cleanliness, uniformity, etc., the advantages are, however, in favor of gas, and in many cases with properly-designed furnaces it is greatly superior to coal, not only from the point of view of cost, but, of course, from such aspects as convenience and ease of manipulation. A properly-designed gas furnace will enable the time of preparation from the cold to be greatly shortened.

The saving in cost is naturally largely dependent upon the effectiveness of the furnace itself. It is desirable that the furnace should be of a size suited to the work to be done by it. It is wasteful to use a large furnace for small work, and rather than to do so it is more economical to erect a small temporary furnace of bricks and fireclay and lagging. For heating bars and such work, temporary furnaces may thus be quickly put up, and if the work changes they can be readily and cheaply altered to suit. Generally it seems to be advantageous for the combustion space, into which the gas flame plays, to be comparatively small. Thus the space surrounding a type-metal melting pot should not have a greater width than 1 inch for pots up to 1 ton and heated by three or four burners. The introduction of tiles of refractory material as baffles often increases the effectiveness of the heating process by raising the temperature and giving a better distribution. Mr. Onslow instances the case of an iron boxed-in hot-plate in which such tiles were substituted for sheet-iron baffles. The box was 6 inches deep, and four burners were provided. With the metal baffles over the burners the temperature on the plate was 110 deg. Fahr., and at the bottom of the box was 65 deg. Fahr. After the introduction of the tile baffles, the temperature on the plate was 200 deg. Fahr., and at the bottom of the box was 165 deg. Fahr. The introduction of firebricks laid flat on the bottom of the box so improved the furnace that two of the four burners became unnecessary for a great part of the day.

A satisfactory arrangement seems to be to have a shop supplied with gas at 200-inch pressure, to be reduced at the various furnaces, etc., by means of governors or valves, to the predetermined pressure corresponding with the temperature it is desired to maintain in each furnace. Pressures suitable for typical work are as follows: For melting tin or solder a pressure of 65 inches is found satisfactory. For small furnaces for hardening, etc., the same pressure may be used. For bluing steel from 65 inches to 80 inches may be adopted, the flames playing horizontally under the lime-tray set in a brick frame. For the lead-pot for tempering steel the pressure should be 150 inches, while for melting metals at from 2,000 deg. to 2,600 deg. Fahr. it should be 200 inches. Soldering irons may be heated with gas at 65 inches, two burners, consuming 6 feet of gas per hour, and playing direct on to the irons, being sufficient to keep a workman going without delays. For lighting, gas at 65 inches may be used.

# The Oldfield Patent Bill*

## Not the Law, But Its Administration at Fault

THE public hearings on the Oldfield bill, which has the object of codifying and revising the laws relating to patents, have already taken over twenty-eight days; they have thus far been published in twenty-eight bulletins, printed by the Government. These bulletins make intensely interesting reading, and will constitute valuable documents for any technical library. Those who desire to obtain copies of the published hearings should apply to the clerk of the Committee on Patents, House of Representatives, Washington, D. C., and should ask for copies of the hearings on H. R. 23417 (Oldfield bill).

Never before was so much direct information collected on the subject of the working of the U. S. patent system. A large number of representative men, among inventors, lawyers, manufacturers, and business men, have appeared voluntarily before the House Committee on Patents; they have had ample opportunity to present their views orally and in writing, and the chairman of the committee, Mr. Oldfield, has shown unfailing courtesy and patience to all who appeared before him.

It is a noteworthy fact that although there clearly exists a great diversity of opinion among the witnesses as to details of proposed reforms, there seems to be a practically unanimous opinion among those who ought to know best, that the defects of the patent system of this country as it is now, do not reside in the fundamental patent law, but in the way the law is administered before the courts. Lawyers and inventors alike point out that the methods of patent litigation in this country are so absurd, so slow, so complicated, and so expensive, that only rich individuals or wealthy corporations can afford to defend a valid patent against infringers, or to contest the validity of a worthless patent.

From this standpoint, the patent system of the United States, is, as has been said in these columns (see Abuses of the U. S. Patent System, by L. H. Baekeland, SCIENTIFIC AMERICAN SUPPLEMENT, vol. 73, June, 1912, p. 346), "a godsend for wealthy corporations, lawyers, and experts."

During the hearings, it has been pointed out repeatedly how this could be remedied by adopting the methods of England, Germany, and other countries, and by eliminating the present absurd system of taking testimony in patent suits and by the creation of a single final court of patent appeals, instead of nine Circuit Courts of appeal which may render conflicting decisions, so that a patent is declared valid in one circuit and invalid in another.

It has also been stated repeatedly during the hearings how the complications, delays, and expenses of the interference system in the Patent Office give an immense advantage to the party with the well-filled purse, and practically eliminate him who cannot pay for lawyers and experts. This might be easily corrected by awarding priority to the diligent inventor, who first files his application, provided he has made the invention independently, and has not obtained it surreptitiously or by fraud from others. After all, the public is only benefited by the inventor who *discloses* his invention, and not by the one who keeps his invention secret, until he is compelled to disclose it in interference by another inventor who applies for a patent. The interference system as it is puts a premium on delays and on jockeying in the Patent Office. These are two relatively small reforms; they only relate to rules of practice, yet they would bring about immense changes for the better. They do not touch on the otherwise excellent fundamental patent law; they are no untried things; they are successfully in operation in practically all civilized countries except the United States.

Unfortunately, the Oldfield bill has entirely overlooked these most vital points, and indicates no remedy whatever. What is worse, the Oldfield bill introduces some reforms which, in the opinion of competent critics, will kill off the best parts of the fundamental patent law. These reforms, if adopted, will practically assassinate the very spirit of the United States patent law, which hitherto has been generally upheld, by foreigners as well as by Americans, as the best patent law in existence. Nor is the latter statement an idle assumption in view of the fact that such countries like Germany, whenever they made a change in their patent law, always came a step nearer to the American patent law.

Foreign writers have been unsparing in their praise of the organic American patent law, even if they lost no opportunity to denounce or to ridicule the absurd methods of practice in equity before the courts of this country.

The Oldfield bill, instead of remedying the defects of the patent system, simply mutilates the very best part of the patent law. The bill is evidently aimed at the trusts and some large corporations which have been abusing the patent laws. Animated by the desire of curbing the trusts, the framers of the Oldfield bill have unconsciously proposed means which will favor wealthy corporations more than ever before. Indeed, as was pointed out at the hearings, Sections 17 and 32 will still further increase abundant opportunities for expensive and long drawn-out litigation.

Someone has defined an American patent as "a license to enter into patent litigation." By Section 17, an American patent will become "a *compulsion* to enter into litigation." Anybody who possesses a valuable American patent will constantly run the risk of being harassed, by suits, to give compulsory licenses under some pretext or another. Valueless patents or those of which the value has not been demonstrated or tried will be left unmolested, but as soon as a pioneer has gone through all the efforts and expenses of introducing his invention, and establishing its merits at his own expense, by creating a successful business, then nothing becomes easier for a wealthy competitor than to take away his "exclusive" patent rights, granted as if in sheer mockery by the constitution. By simply inventing an *improvement* on the original invention, and suing the pioneer inventor for a compulsory license, he can easily make him divide his monopoly and make him compete afterwards with the wealthier and more powerfully organized corporation.

If nowadays there is still some possibility for a patentee to compete with large corporations, this will soon disappear if this Section 17 passes. This provision is so hopelessly bad, so indefensible, that even the originators of the Oldfield bill seem to admit its dangers. The compulsory license clause in case of non-working of the patent is just as dangerous an opportunity for business pirates for jumping at the throat of the patentee while he is in the difficulties of pioneer work and saddling him, against his will, with expensive compulsory license suits, and to ask him; "Your invention or your business life." Germany at least only allows compulsory licenses in rare cases; for instance, safety appliances or inventions for national defense where the public welfare is involved.

Section 32 is almost as bad, because it takes away from the patentee the right to stipulate conditions under which to license, vend or lease his inventions to others. This Section 32 has been aimed specially against resale price restriction; but the framers of the bill have upset unwittingly the very essence of the patent law and of the provisions of the constitution which guarantee to the patentee, or his assigns, seventeen years of "*exclusive* right to make, use and vend the invention."

Evidently, those who drew up the Oldfield bill are or were not aware of what an immense amount of mischief and injustice these two sections of the bill would cause, and they remind one of the man who set fire to his barn in order to destroy a hornets' nest. If this Oldfield bill passes as presented, it may be a real calamity for the industrial and intellectual development of this country.

The most eloquent result of the hearings is that among all the many witnesses who have appeared, there was practically unanimous denunciation of Section 17 and Section 32, as framed. One of the very few who were in favor of Section 32, was a lawyer retained by a large Chicago drygoods store, and it was alleged by his critics that this store had frequently violated its business contracts as to selling agreements. On the whole the large majority of those who have given careful thought to the Oldfield bill agree that Sections 17 and 32 would be a great boon to business pirates, habitual infringers, or those who live by appropriating the work or pioneership of others.

The single taxer and the socialist may use their arguments against private ownership of landed property which has always existed before it was owned privately and of which the private owner reaps the benefits of the unearned increment conferred upon it by the efforts of the community. Yet the landowner may let his land lie idle and unproductive to the detriment of his neighbors, and the community at large; furthermore, his title of property or monopoly runs forever.

Why then should an unjust discrimination be made against intellectual property, the most justifiable form of private property, and of which the private ownership exists only for the short period of seventeen years, after which it is confiscated for the benefit of the public?

The status of patent property has been well defined by Albert Walker, in his textbook of patent law: "Patents are property, the owner of a patent is legally and equitably entitled to the same protection that the owner of any other species of property may enjoy. . . . The right of property which an inventor has in his invention is excelled in point of dignity by no other property right whatever. It is equaled in point of dignity only by the rights which authors have in their copyrighted books. The inventor is not the pampered favorite of the Government or of the Nation. The benefits which he confers are greater than those which he receives. He does not cringe at the feet of power, nor secure from authority an unbought privilege. He confers upon mankind a new means of lessening toil or of increasing comfort, and what he gives cannot be destroyed by use nor lost by misfortune. It is henceforth an indestructible heritage of prosperity. On the other hand, he receives from the Government nothing which cost the Government or the people a dollar or a sacrifice. He receives nothing but a contract which provides that for limited times he may exclusively enjoy his own. Compared with those who acquire property by gift or marriage, compared with those who acquire property by profits or sales or by interest on money, the man who acquires property in inventions, by creating things unknown before, occupies a position of superior dignity. Even the man who creates value by manual labor, though he rises in dignity above the heir, the donee, the merchant, and the money lender, falls in dignity below the author and inventor. . . . *No inventor has any special right in his invention at common law.* This is not a virtue in that law. It is an imperfection, an omission."

Whatever tends to increase and multiply the causes which may involve patent property in litigation, or to render that litigation more complex and ruinous, certainly works to increase the existing insecurity of patent property. The proposed law, if made effective, would overburden the inventors with litigation uncertainties beyond anything which can at present be estimated.

No one proposes that the principle of compulsory license be applied to landed estates or to any other form of property, however it may have been acquired. Patents are treated as if they were privileges, when, as a matter of fact, a patent to a valid invention of economic and social value is merely a public recognition of an inherent right. If there is reason why the inventors should be compelled to divide their property rights with others, who have in no way contributed to their development, especially along the lines proposed, in Sections 17 and 32 of the Oldfield bill, there is even greater reason why the same principle of extraction should be made operative against other forms of private property rights. It does not promote the progress of the useful arts to expose the inventors to dangers which they cannot meet.

It is neither good public policy nor good reason, and certainly not justice, to penalize the inventors because they cannot market their inventions or bring them to the stage of commercial use in the face of legal and economic obstacles created by the long-continued abuse of patent rights and the progressive degradation of the patent system. It is not justice that the inventors should be compelled to surrender their inventive and economic independence, or the prospect of this independence, because society, in its long neglect of their rights, needs, and interests, has permitted a condition to grow up under which the patent system is cunningly and systematically employed to defeat the very aims for which it was created by constitutional provision.

Now that the hearings have disclosed the dangerous mistakes of some of the provisions of the Oldfield bill, it becomes self-evident that this bill ought to be amended considerably before it be submitted again.

If it be redrafted, let provisions be included to simplify and to render less expensive, all actions in equity as well as patent interference proceedings.

[The writer might have added that if Congress has the right to legislate as proposed by the Oldfield bill concerning patent property, it follows that it also has the right to so legislate concerning all forms of property. If a patentee may be compelled by compulsory license to divide his created property, the subject of patents, with his neighbor, the owner of other property acquired by gift, purchase or devise can also be compelled to divide such property with his neighbor. If,

* *Metallurgical and Chemical Engineering, July, 1912.*

on the other hand, it be admitted that Congress has no right to so legislate concerning all kinds of property, then it follows that it has no such right of legislation concerning patent property. In our opinion, therefore, any legislation which in the slightest degree affects the *exclusive* character of the grant to an inventor is absolutely unconstitutional. It is true that the constitutional provision is not mandatory concerning the grant of patents to inventors, and it may be regarded as expressing merely the will of the framers of the Constitution as to the location of the power to protect inventors in their rights to the property which they create, in one of the co-ordinate branches of the Government, namely, Congress. The framers of the Constitution delegated to Congress the authority to legislate for the purpose of securing to inventors the exclusive rights of property for a limited time. There is nothing in the Constitution which authorizes Congress to enact any laws which shall secure to the inventor anything less than the *exclusive* right to his invention, and because the provision of the Constitution as before stated is not mandatory, Congress may refuse to pass *any* laws securing to inventors their property rights in the things which they create, and it, therefore, rests with Congress alone to determine the period of security which it may grant to inventors, yet, if it pass any laws to this end, they must, as directed by the Constitution, secure to inventors *exclusive* rights, during the term of such grant.

It is to be hoped that Congress will not enact any legislation affecting the patent laws without giving thereto more careful and thorough consideration than has been given to the proposed legislation. In this connection, we urge that a commission of experts be appointed to make a thorough and exhaustive study of the situation, and upon its report, such legislation as may be recommended be enacted. Hasty legislation of the sort here discussed can do no one any good, but can work havoc with our patent system to be ultimately overturned by the Supreme Court as unconstitutional.—EDITOR OF THE SCIENTIFIC AMERICAN SUPPLEMENT.

# Vocational Disabilities Due to Defective Color Sense

## A Handicap More Common Than Generally Supposed

IT is increasingly recognized that fitness of physique as well as of intellect is a requisite for the highest success in any given vocation, and correspondingly that certain defects of the body and particularly of the organs of the special sense may militate seriously against quantity or quality of output in one occupation while inoperative or negligibly detrimental in others.

This is peculiarly true of the eye. Both myopia and presbyopia may be cruel handicaps in some directions and actually helpful in others, since near-sighted persons are said to be the best diamond experts, while farsightedness is directly advantageous in many out-door pursuits. Moreover, both these defects, as well as astigmatism, etc., may be remedied by the aid of the oculist and optician. But there remains another native defect of the eye for which as yet no remedy has been found, and which has indeed been recognized and studied only in comparatively recent years. This is the lack of sensitiveness commonly known as "color blindness." Persons afflicted with this are now excluded from such position—chiefly in traffic on land or sea—as require discrimination between signals of different colors, officials of railroads and ship lines having been educated to demand such exclusion by the brutal but effective object lessons of disastrous accidents.

That many persons not actually "color blind" in the extremest degree are nevertheless afflicted with a weakness or partial defectiveness of this ocular power is the statement made by Dr. Alfred Guttmann in a recent number of *Die Umschau*. Dr. Guttmann, who is the author of a volume on Defectiveness of the Color Sense, is an authority on the subject, and his conclusions are worth careful consideration, especially in relation to the choice of a vocation by a person so afflicted.

He finds that most people have a somewhat confused and inaccurate idea as to the exact nature of the affection in question. "One of ten hears it said," he observes, "that such persons can distinguish all the other colors, but that red and green look alike to them." But this he declares erroneous.

"The so-called 'color blind' are neither blind to colors nor do red and green look the same to them. *But they confuse a remarkably large number of colors (red and green among them), between which the normal eye discriminates.*

"A rainbow, like every spectrum, contains the familiar seven principal colors, violet, indigo, blue, green, yellow, orange, red, scientifically differentiated by their wave length. Colors which have a wave length of about 700 to 650 $\mu\mu$ are called red, a wave length of about 530 $\mu\mu$ is green, 480 $\mu\mu$ is blue, and the boundary of the spectrum visible to us is found at about 400 $\mu\mu$.[1]

"The normal eye can distinguish the red of 650 $\mu\mu$ from the orange light whose wave length is 647 $\mu\mu$. A still more delicate discrimination is made between yellow and green, while among the yellow tones differences of 1 to 2 $\mu\mu$ may be detected. The color blind person, on the other hand, sees no difference between all these hues from the extreme red (cc. 760 $\mu\mu$) up to the blue-green (cc. 550 $\mu\mu$). To the normal eye all these shades appear as different colors of varying degrees of brightness, the color blind see a band of uniform color whose different portions vary in brightness.

"This colored band appears yellowish or reddish to him, while the remaining part of the spectrum looks bluish to him. To the normal eye, violet is a color distinctly different from blue; to the color-blind it is only a darker blue. He sees, therefore, the many colored spectrum in *two colors only*. The first strip (about 760 — 500 $\mu\mu$), appears to his eye 'warm,' (yellowish or reddish); the other strip (cc. 500 — 400 $\mu\mu$) looks 'cold' (bluish). The normal eye can distinguish about 160 tones in such a spectrum, the color blind only two!

Within each of these bands he perceives only varying intensity of light."

The disabilities experienced with the pure tones of the spectrum are equally marked with those shades produced by mixing these tones with black or white or with each other "all brown tones are merely mixtures in varying proportions of yellow and gray; purple (not found in the spectrum) is blue and red; lilac, white and violet. The color blind confuse these mixed colors also; brown, for example, is taken, according to its brightness, for red, orange, yellow, green, gray, or pink."

Dr. Guttmann next considers the subjective aspect of color blindness. Since afflicted children learn the names of the colors, it is interesting to inquire what meaning they attach to them. Such children, he believes, gradually learn to distinguish varying intensities of light in the "warm" color band and the "cold" color band, and he maintains that immense numbers of people use the names of colors without having any knowledge that they really do not see these colors, an opinion reached after the statistical examination of many thousand persons. This is partly due to the fact that any one who has been ridiculed for misnaming a color learns to refer to objects without mentioning the color.

Furthermore, the diagnosis of color blindness is not such a simple matter as has been heretofore believed.

"Besides the color blind group above described there is a second group of persons having an anomaly of the color sense." That is, though not entirely color blind, the color sense is feeble or non-sensitive. "Such persons are about as numerous as the color blind; i. e., 3 to 4 per cent of all. They can distinguish all the colors of the spectrum, but are far from being able to detect so many shades as those of normal visions, e. g., yellow and greenish yellow look alike to them except in intensity, and it is the same with blue and violet. Furthermore, there are many juxtapositions of color such as occur in every day life, which *they find precisely as difficult to discriminate among as do the color blind.* This is chiefly true when the objects are small and far distant. A strawberry or a cherry in the hand he can see plainly, but cannot distinguish among the foliage of the tree or on the ground."

According to the author such persons also have difficulty in distinguishing pale or dull colors, such as dark red, pale pink, and grayish-green, as also very bright colors, such as the red Bremer light, the green Patina, and the green Bengal light. They are also strongly affected by the influence of juxtaposed colors. "The color contrast is so accentuated in them that in the vicinity of a distinct red color all other colors (yellow, brown, green, even pale orange or pink), look green." Moreover, their color sense is quickly fatigued, and they require an abnormally long time for the determination, so that they are unable to recognize a color at a glance, like normal person's or to take in a distinct impression of several colors instantly.

It is obvious from the foregoing considerations that there are many occupations in which the "color blind" or the "color weak" individual would be at a marked disadvantage because of the time wasted in making discrimination or because of actual mistakes made, which might involve a further waste of time for rectification, a large money loss, or even, conceivably, the sacrifice of life, as in a mistake made between two drugs, similar of aspect except for color. The color blind are less conspicuous than the color weak, since the latter, instinctively or consciously, try to bring the colors closer to the eye.

Such disabilities as the ones just discussed are practically prohibitive in railroad or marine service. The color blind have long been excluded from them, and Dr. Guttmann's studies have caused the same rules to be applied, at least in Germany and Austria, to the "color weak."

Other professions are, however, fully open to them and Guttmann believes this to be disadvantageous, both to them and to the public, since they must fail to exhibit the efficiency of normal individuals in many instances without recognizing the true cause of such failure.

It is obvious that a delicate sense of color is valuable if not indispensable, in those trades which deal with luxurious commodities, such as jewels, fine fabrics, carpets, decorations, upholsteries, and hot-house flowers. Clearly, too, such a color sense is necessary not only to artists, but to architects, to landscape gardeners, to stage managers, to cabinet makers, metal workers, artificial flower makers, and a host of other craftsmen.

But Guttmann points out also its immense practical importance in agriculture and horticulture. The distinction between ripeness and unripeness, or ripeness and decay is commonly marked by variations of color—and the farmer or fruitman must be able to distinguish between red and green, green and brown, and brown and red, or even red and purple in the case of grapes and plums.

Color determination is also frequently of vital importance in chemistry, physics, geology, zoology, and botany, which it is absolutely indispensable to the physician as a means of diagnosis in some cases, such as skin diseases, inflammations, fevers (e. g., yellow fever, scarlet fever, typhoid, etc.). Other maladies, too, may be indicated by the pallor, the grayish look, the jaundiced hue, or other discolorations of skin or mucous membrane.

The great domain of bacteriological and chemical investigation (e. g., the color method of detecting the tubercle bacillus, sugar determination by polarization, the examination of urine, etc.) makes like demands on the color sense.

Dr. Guttmann further specifies a great number of industries where unimpaired color sense is indispensable, such as dyeing, paint and varnish manufacture, book-binding and printing of the finer sorts, photography, food preserving, etc.

In all these various fields individuals thus afflicted are subject to constant mistakes and accidents, which are only too frequently ascribed to lack of care or attention, so that they are handicapped and prevented from rising above inferior positions without realizing why.

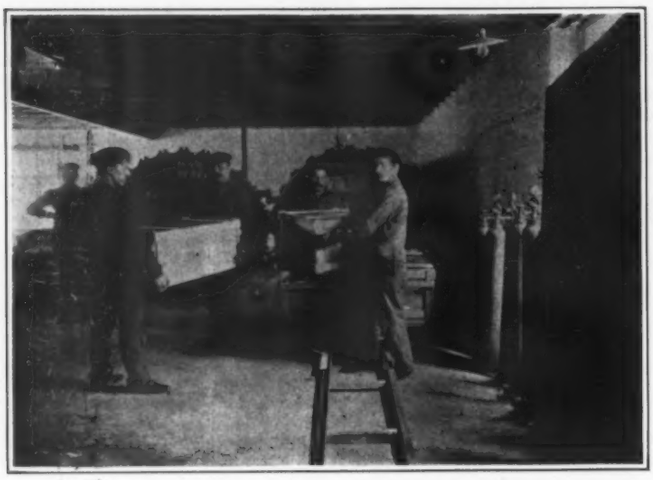
Dr. Guttmann, therefore, earnestly advises the careful inspection of all school children, at least a year before leaving school, by competent physicians, with respect to this faculty, so that they and their parents may be advised as to those trades and professions for which they are imperfectly fitted. Such examination would eliminate many "misfits," and, therefore, redound to the advantage both of employers and employees.

[1] The hundred thousandth part of a millimeter is denoted by $\mu\mu$.

**Spanish Iron Minerals.**—Iron minerals have been a source of wealth to Spain for the last quarter of a century, and their production has considerably increased during that period. The production and exports have been as follow during the decade, ending with 1910.

| Year. | Production. Tons. | Exports. Tons. |
|---|---|---|
| 1901 | 7,780,000 | 6,783,000 |
| 1902 | 7,778,000 | 7,438,000 |
| 1903 | 8,171,000 | 7,568,000 |
| 1904 | 7,837,000 | 7,175,000 |
| 1905 | 8,931,000 | 8,452,000 |
| 1906 | 9,297,000 | 9,123,000 |
| 1907 | 9,738,000 | 8,497,000 |
| 1908 | 9,123,000 | 7,136,000 |
| 1909 | 8,645,000 | 8,048,000 |
| 1910 | 8,650,000 | 8,113,000 |

It will be observed that the production of Spanish minerals attained its maximum in 1907, and that since then it has somewhat declined.—*Engineering.*



Conveying the Metal Cases to the Gas Tank in Which They Are Sterilized.

Stacking the Eggs Before Treatment in the Gas Tank Seen in the Rear.

# A New Process of Preserving Eggs

## Carbonic Acid and Nitrogen Gas as Sterilizing Agents

A FRENCH engineer, M. Lescardé, has developed a new process for preserving eggs, which is said to be much superior to the common cold storage method. The process has reached the manufacturing stage, and plants are starting operations, one in France and one in Belgium. As everyone knows the ordinary methods of cold storage for eggs are far from perfect, partly, perhaps, because certain microbes withstand freezing temperature without serious hurt; moreover, eggs as ordinarily handled are affected by the surrounding air through the effects of evaporation. For these reasons prolonged cold storage markedly impairs the value of eggs.

It is found that by the Lescardé process eggs may be kept as long as ten months, while the limit for the cutomary process is about four months. Moreover, the eggs stored on the new plan retain a much better quality. The inventor, in fact, claims that they can be sold as fresh eggs, and that it is impossible to detect any difference.

In carrying out the Lescardé process, the eggs are set up upon a piece of cardboard provided with a number of suitable perforations. There are 160 holes in each slab, which forms the cover of a tin-lined wooden box containing two incandescent lamps, so arranged that the light passes through the eggs and is viewed by the operator. It is thus easy to detect any spoiled eggs, and it takes but a few seconds to examine the entire 160 eggs.

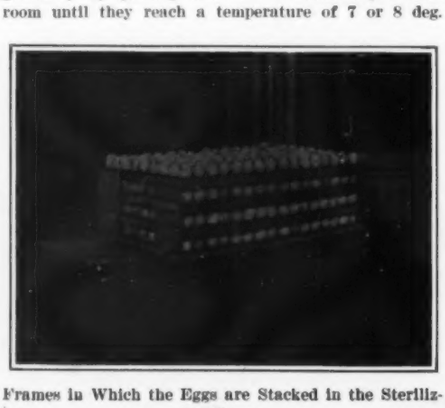
The next stage, which is illustrated in one of our engravings, consists in packing the eggs in special metal boxes, in which they are treated with carbonic acid gas and nitrogen. The room in which this step is carried out is kept cooled to a rather low temperature.

The eggs are fitted into perforated frames, which are placed in sheet-iron boxes holding six frames of 160 eggs each, or 960 eggs in all. The sheet-iron case is surrounded by a wood framing so that it can be handled readily and the boxes can be stacked up in the apparatus. When the box is filled with eggs, a small amount of chloride of calcium is put in to absorb the greater part of the moisture of the air, and then the cover is soldered on, leaving a small hole in the top for the circulation of air or gas. The boxes are then ready to be taken to the sterilizer, which consists of a large cylindrical tank, seen in the rear of one of our illustrations. The boxes are stacked upon roller truck, which are then run upon rails to the tank, a considerable number being treated at a time. The cylinder has a tight closing door, and resembles an injecting cylinder for treating railroad ties. The tank is first of all exhausted to extract the gases or air from the air-pocket of the eggs, and also the gases dissolved in the albumen. After this has been done, carbonic acid gas is sent into the apparatus from steel bottles containing compressed or liquefied gas. As the gas which leaves the bottles becomes very cold owing to its expansion, it is warmed somewhat to prevent cracking of the eggshells. For this purpose the gas is run through a worm tube placed in a tank of warm water. The pressure in the tank is observed by means of a gage. After admitting a certain amount, the gas is shut off for a time, while it continues to be absorbed by the albumen of the eggs. Fresh gas is then let in when the pressure is seen to fall, and this is kept up until the eggs absorb no more gas. When the proper point in this operation is reached the carbonic acid gas is shut off, and a portion of it is then again extracted by pumping, to be replaced by a certain amount of

Examining Eggs by Their Translucency to Light.

nitrogen fed from compressed gas cylinders. The eggs are then ready to be removed from the tank, and the trucks are rolled out, after which the workmen solder up the small inlet opening. As the pressure in the box is above atmospheric, there is no danger of air leaking in.

The eggs are now ready to be taken to the cold storage quarters, where they can be kept for a long period of time. These storage rooms need no special precautions as to the state of the air or the amount of dampness, as this can have no effect upon the eggs. Accordingly the storage chambers are cooled by a simple brine circulation, and the temperature is kept about at the freezing point. The eggs are thus stored for the proper length of time until they are needed for use, and are then removed. The boxes are first heated gradually by placing them in a moderately heated room until they reach a temperature of 7 or 8 deg.



Frames in Which the Eggs are Stacked in the Sterilizing Boxes.

Cent. if the outside air is at 15 degrees. Then the boxes are opened and the eggs can be packed and shipped in the usual way. The cost of carrying out the Lescardé process is but little greater than that of the usual cold storage method, as there is no great expense for the gas-treating plant, and the slight extra cost is more than made up by the greater market value of the eggs when treated by this process.

### Temperature and the Typhoid Bacillus

THE effect of temperature upon the vitality of the typhoid bacillus in raw Thames River water formed the subject of part of the seventh research report, recently issued by Dr. A. C. Houston, director of water examination to the Metropolitan Water Board, London. In all previous experiments the temperatures, being those of the laboratory, had been considerably higher than those of the outside air. It was accordingly considered desirable that trials should be made so as to embrace a wide range of temperature. Six stoppered bottles, each containing 150 cubic centimeters of raw Thames water, were severally inoculated with one cubic centimeter of typhoid emulsion, and the bottles, which were about three parts full, were stored in the dark in ice chambers or incubators, according to the temperature desired, which accurately registered and maintained the following temperatures, in degrees Fahrenheit: 32, 41, 50, 64.4, 80.6, 98.6.

At weekly intervals, after shaking so as to include the sediment, the contents of the bottles were examined. At the end of the first week positive results were obtained in all the samples. At the end of the second week a negative result was obtained with the mixture kept at 98.6 deg. Fahr., the highest temperature. At the end of the third week there was a negative result with the mixture kept at 80.6 degrees. The end of the fourth week showed a negative result with a temperature of 64.4 degrees, and the end of the fifth week with a temperature of 50 degrees. Seven weeks elapsed before all the bacilli in the mixture kept at 41 degrees were dead, and nine weeks were required to entirely exterminate all the microbes in the mixture kept at the freezing point.

For seven months in the year the average outside water temperature is higher than 50 degrees. At this temperature there were no bacilli alive at the end of the fifth week, while at the end of the third only an average of three per cubic centimeter persisted, the average initial number being 103,328 in the same volume. During the remaining five months of the year the average water temperature is about 41 degrees, a temperature at which, although it is said to be decidedly less favorable to the rapid death-rate of the typhoid bacillus, still reduced, on the average, the initial number in four weeks from 103,328 to 3, the worst result showing a reduction from 23,333 to 12 in this time.

The typhoid bacilli used in this experiment were cultivated, and hence more persisent than uncultivated bacilli, and by the second week the reduction was over 99 per cent on the average. The conclusion is that although there is all this reduction at the end of the second week, it is specially desirable that the water should be adequately stored antecedent to filtration.—*The Engineering Record.*

# Forcing Plants by Means of Radium

## Treatment Must Be Applied During "Period of Rest"

By Dr. Alfred Gradenwitz

MAN is no longer content with having each plant at its own season. In fact, endeavors have been made for some years to abridge the period of rest of vegetables by different means such as refrigeration, etherizing, hot baths, lesions, and injections.

Four Sprouts Exposed Respectively for 48, 24, 1 and 0 Hours to Radium.

As regards the action of radium on vegetable life the results so far obtained are somewhat contradictory. While growth was generally found to be delayed, some cases are also on record of the germination of grains being accelerated by radium.

Dr. H. Molisch, professor at the University of Vienna, who had for some time been engaged in an investigation of the influence of radium and its emanation on plants, recently tried to ascertain whether radium rays or radium emanation would influence the period of rest so as to accelerate the sprouting of plants. The experiments, of which an account was given to the Imperial Academy of Science, indeed show the radiation of radium products to possess the striking property of shortening the period of rest of the winter buds of certain plants, causing these buds to sprout prematurely. If, for instance, the terminal buds of *Syringa vulgaris* are exposed to the radiation of strong radium products for one or two days at the end of November or December, these buds, afterward cultivated in the hothouse, are found to sprout very soon, whereas those left untreated only develop much later. While the action of the radiation must be continued for a certain time if this effect is to be produced, it is liable, if prolonged too much, to have effects harmful or even fatal to the plant. In September and October, that is, at a

The Sprouts on the Left Were Kept in Pure Air. Those on the Right Were Exposed for 48 Hours to Radium Emanation.

time of deep rest, the action of radium is quite ineffective. If, on the other hand, the experiment be put off until January or even later, when the period of rest is over, no difference can be observed between buds exposed to radium and those that are not, unless in fact the former be delayed more or less in their growth. This behavior is quite similar to the influence of ether or warm-water baths.

Radium emanation exerts on the development of buds an even more pronounced action than solid radium products. It is also better adapted for activating the growth of plants, owing to its more uniform action, that of solid radium products being limited to a very small area. At a certain stage of the period of rest (November and December) emanation experiments give particularly good results. The action of emanation otherwise shows about the same behavior as that of solid products.

Apart from *Syringa vulgaris*, Prof. Molisch obtains satisfactory results also with the following trees and shrubs:

*Aesculus Hippocastanum*, *Siri Liriodendron tulipifera*, *Staphylea pinnata*, and *Acer platanoides*.

Though this forcing process is too expensive to have, at least for the present, any practical importance, the peculiar effects of radium still deserve the attention of biologists, the more so as products of equal intensity generally exert on growing vegetable organs quite different effects from those observed during the period of rest.

Sample (1) Grown in Ordinary Air; (2) Exposed to Emanation for 20 Hours; (3) for 48 Hours; (4) for 72 Hours.

# New York's Enormous Annual Coal Consumption*

## The Coal Tonnage of New York City

By F. E. Seward

THE coal tonnage of the largest American city has always been a topic of interest to the trade. It has never been an easy matter to ascertain the tonnage used, as precise data are unavailable.

EARLY FIGURES ON THIS TOPIC.

Prior to the expansion of the city limits, it used to be said that 6,000,000 tons would cover requirements; then after Brooklyn, Queens and Richmond were added on, the tonnage was estimated at 12,000,000 tons; and in 1905, when certain Government statistics relative to coal supplied to New York city and harbor points were first made available, the amount sent to destination within the limits of greater New York, so styled, was, in round numbers, 15,500,000 tons.

At that time—seven years ago—there were some 24,000,000 tons of hard and soft coal shipped at loading ports in New York harbor—the city requirements constituting, it will be noted, 65 per cent of the business of the New York loading ports. Nine million tons of the amount shipped to New York city was anthracite—(60 per cent of the 15,000,000 tons of anthracite shipped in the harbor)—and 6,500,000 tons was bituminous, say 72 per cent of the 9,000,000 tons of bituminous handled at the piers in and about New York in the year named.

TONNAGE REQUIREMENTS OF 1908.

While these details of distribution are no longer available, the statistics of 1908 indicated that anthracite shipments at New York harbor points were 15,-039,981 tons; the bituminous shipments, 10,247,014 tons. Estimating about the same proportion of distribution as in 1905 (for which policy there appears to be good authority), would give the result of, say, 10,050,000 tons of anthracite and 7,800,000 tons of bituminous—a total of 17,850,000 tons as the annual coal requirements of the city of New York in 1908, including the steamship or bunker business (the tonnage of which is burned, almost entirely, outside of the city limits).

THE REQUIREMENTS OF TO-DAY.

It seems very probable that the development of New York, particularly in the outlying section—has offset any of the frequently-mentioned reductions arising from economies in the domestic trade, and changes of fuel made by householders, with the more extended introduction of gas and coke. And in the steam trade, so much of the New York tonnage goes to public utilities and other enterprises that operate on a full-time basis the year around, that we do not have to consider locally the variations in coal tonnage requirements that prevail from time to time in manufacturing cities east and west.

Having these circumstances in mind, we give below estimates of hard and soft coal destined for New York use. Proportion of anthracite has been calculated at an increased figure—70 per cent, instead of 60 per cent—as it is probable that more hard coal is going east all-rail, and a larger amount of coal shipped at local ports is for city use. Probably the increase in bituminous coal used locally is in proportion to the increased tonnage used in eastern centers, and no change in percentage thereof seems advisable. Applying these percentages to the figures of harbor loadings appearing in the *Coal Trade Journal* (Manhattan), the local record stands as follows: Anthracite used, 11,000,000 tons; bituminous used, 3,500,000 tons for miscellaneous purposes, and 4,684,846 tons for bunker tonnage.

WHERE DOES ALL MANHATTAN'S HUGE COAL SUPPLY GO?

The distribution of utilization is about as follows:

| | |
|---|---|
| *Anthracite*— | |
| Domestic, private houses, and small stores using mostly "egg," "stove," and "nut"—about one fourth of the total | 25 per cent |
| Flats and apartment houses, heating, etc., using mostly broken and egg, or pea and buckwheat sizes—under one third of the total | 33 per cent |
| (The two preceding items—some 58 per cent, aggregating a little more than one ton per capita—may be termed the domestic trade.) | |
| Hotels, clubs, theaters, factories, institutions, etc.—about one tenth of the total | 10 per cent |
| Gas and electric requirements, estimated from annual reports—about one tenth of the total | 10 per cent |
| Department stores, office buildings, etc. | 10 per cent |
| Elevated, subway and surface railroads—about one fourth of their total tonnage | 4 per cent |
| Steamboats, tugs, and shipping, also steam railroad fuel, for heating, etc., within city limits | 4 per cent |
| Municipal requirements (city departments) | 4 per cent |
| Total anthracite (about) | 11,000,000 tons |

* *The Coal Trade Journal.*

*Bituminous*—

| | |
|---|---|
| Steam trade, factories, refineries, etc., including gas and electric plants (about) | 25 per cent |
| Steamship bunkering (official returns) | 50 per cent |
| Elevated, subway and surface railroads | 17 per cent |
| Heating stores, office buildings, etc. | 5 per cent |
| Blacksmith trade, including carriage manufacturers | 2 per cent |
| Municipal requirements, pumping stations, etc. | 1 per cent |
| Total bituminous (about) | 8,236,000 tons |
| Total anthracite and bituminous | 19,236,000 tons |

In addition, there is used an estimated coke tonnage (gas house) amounting to 225,000 loads of 50 bushels each.

Population by the census of 1910 was approximately 4,700,000, exclusive of borough of Richmond, where suburban or rural conditions prevail in the coal trade and otherwise. Manhattan and Bronx may be put down for 2,765,000 population, and are generally considered together in coal trade matters. If division of tonnage is made, as between these boroughs, it should be on the basis of six sevenths and one seventh. Brooklyn may be set down as having 1,635,000 population, borough of Queens 285,000. This trade runs together in the Jamaica and Long Island City territory, where the heaviest business of the Queens dealers is done. Together the two boroughs have some 1,920,000 population, or, say, two fifths as many as the entire city, and a little over two thirds of the Manhattan and Bronx population.

On this basis we can therefore divide the coal trade by boroughs as follows:

Anthracite—Manhattan and Bronx, 6,550,000 tons; Brooklyn and Queens, 4,350,000 tons.

Bituminous—Manhattan and Bronx, 2,087,000 tons; Brooklyn and Queens, 1,350,000 tons.

Bunker business cannot be divided by boroughs. Odd amount of hard and soft coal not covered in the above distribution may be set aside as tonnage used on Staten Island.

The following distribution of tonnage in the borough of Brooklyn is furnished to us:

To steam users, including all sizes and grades of anthracite and bituminous, 2,000,000 tons.

To apartment houses, hotels, stores, etc.—all anthracite, in sizes from pea up to broken, with small percentage of No. 1 buckwheat—1,500,000 tons.

To families—all anthracite, in sizes egg, stove and nut principally, with a very small percentage of broken and pea—1,000,000 tons.

The borough of Queens will take a greater proportionate amount of coal than Brooklyn, on a per capita basis, because of manufacturing interests in the Long Island City section and the tonnage of coal used for railroad purposes. There is practically no coal used for railroad purposes, on locomotives, in Brooklyn, and very little in Manhattan. A moderate tonnage is delivered to engines in the borough of the Bronx.

The amount indicated as requirements of the local railroad interests, may be sub-divided in general as follows: Brooklyn Rapid Transit Co., 500,000 tons hard coal, 150,000 tons soft coal; the former Metropolitan Street Railroad lines, 350,000 tons in all, of which about 200,000 tons is buckwheat coal. The balance of the tonnage is used by the subway and elevated power houses in the several boroughs, and is about equally divided between hard and soft coal.

Probably the largest industrial consumers—if they may be so called—are the breweries, of which there are about thirty-five in Manhattan alone. In the Bronx, Brooklyn, Queens, and Richmond there are about as many more. The largest concerns in this class are Ehret and Ruppert, each of which uses about 20,000 tons of broken coal per annum. The others use between 5,000 and 6,000 tons each, as an average, so that in all about 250,000 tons are sold to trade in Manhattan and about half a million in the entire city.

# Experiments on Durability of Tool Steel*

## Cutting Tests at Different Cutting Speeds and With Different Cooling Mediums

By Edward G. Herbert

THE durability of a tool is measured by the length of tube it will turn away before attaining a measured degree of bluntness. Tests made at a succession of cutting speeds from 20 feet per minute upward were reported in a former paper by the author and showed a very low durability at the lower cutting speeds; an increase of durability as the cutting speed increased; a maximum durability at cutting speeds of 50 to 80 feet per minute; and a decline of durability to a very low value as the speed was further increased. The theory was put forward that the observed changes in the durability of cutting tools are mainly caused by changes in the temperature of the cutting edge, due to varying quantities of heat generated at different cutting speeds. The heat theory was confirmed by experiments showing that changes of durability corresponding to those which occur under varying cutting speeds can be produced by varying the temperature of the tool in other ways while the cutting speed remains constant, viz., by varying the temperature of the water with which the tool is flooded; by varying the depth of cut (a heavy cut generating more heat than a light one), or by dispensing with the cooling water.

LOW DURABILITY AT LOW SPEEDS AND FINE CUTS.

It has been found by experiments on the tool steel testing machine that all tool steels, without exception, have a very low durability and are very quickly blunted when cutting under water at low speeds and fine cuts under conditions which preclude any considerable heating of the cutting edge; and it has been found that any alteration in the cutting conditions which tends to increase the temperature of the cutting edge, results in an increased durability of the tool.

All varieties of tool steel have been found to be capable, when suitably hardened, of producing double-peaked speed-durability curves, the characteristics of such steels being that at a certain speed they are less durable than at higher and lower speeds.

The principal action to which a tool is subjected in cutting is one of friction under heavy pressure. This tends to rub the surface of the steel away, by causing the particles of steel to slide over one another. To resist blunting by this action a tool must possess hardness. But the stress on the tool point is not constant; as the chip is detached it breaks up into a series of short segments (more or less completely separated), and this process subjects the tool to a succession of changes of pressure, amounting almost to blows, and tending to chip off portions of the cutting edge. To withstand this action the tool must possess toughness.

In order to measure, throughout a range of temperatures, those physical properties of a steel which constitute its durability, it is necessary to test it at each temperature for hardness and for toughness. The method finally adopted was that of breaking the specimen, supported at the ends on knife edges, by a load applied transversely at the center. The apparatus employed is illustrated in Fig. 1. The specimen *A* was in all cases 3 inches long, ¼-inch deep and ½-inch wide. It was supported on knife edges *BB*, 2½ inches apart. A third knife edge *C* was affixed to a plate *F*, and guided by pins *DD* sliding freely in holes in *F*. The whole was placed in a bath containing water, oil or salt, according to the temperature under investigation, the specimen being completely immersed in the liquid. The bath was rested on iron blocks *GG*, with gas burners or blow pipes between them, and the whole was placed under the cross-head of a 100,000-pound autographic testing machine.

Some of the resulting diagrams are reproduced in Fig. 2. The height of each curve represents the maximum load applied to the specimen to break or bend it, and this maximum load is taken as a measure of toughness. Curve *a* is from a specimen broken cold; being brittle, a small load sufficed to break it. Curve *b* is from a similar specimen broken at 238 deg. Cent. (460 deg. Fahr.). It was tougher, and broke at a higher load. Curve *c* is from a specimen tested at 278 deg. Cent. In this case the specimen was very tough. It supported a heavy load, and bent with breaking. Specimen *a* was very hard; it gave only a small deflection for each increment of load, and the resulting diagram is nearly vertical. Specimen *b* was softer, and *c* very soft, and the slope of the diagram was greater as the hardness diminished. Numerically the hardness may be expressed as the load required to produce 1/10-inch deflection, and the hardness number is obtained by dividing the maximum load in pounds by the deflection in tenths of an inch.

EXPERIMENT WITH CRUCIBLE STEEL TOOLS.

Experiments were first made on a crucible steel containing about 1.3 per cent carbon. A bar ½ × ¼-inch in section was cut into pieces 3 inches long, which were heated to 800 deg. Cent. and quenched in water. Some of the specimens were left in the dead-hard state, others were tempered by being placed for 15 minutes in an oil bath at 136 deg. Cent. Others were tempered in like manner at 145 degrees and 175 degrees, respectively.

The results of the breaking tests are plotted out in diagrams *A*, *B*, *C*, *D*, Fig. 3. The full lines in these diagrams represent maximum loads at which the specimens were broken or bent (toughness), and the dotted lines represent the hardness, or maximum load divided by deflection. We have here, according to our theory, two of the elements for determining the variations of durability with temperature; but it is very difficult to say, from inspection of the curves, which temperatures might be expected to give the highest durability to the steel. The durability will be high when both the hardness and toughness are high. The durability will be low when either the toughness or hardness, or both, are low.

It is evident that if we multiply the hardness number by the corresponding toughness number for each temperature, we shall obtain a new series of numbers fulfilling the conditions just stated—they will be high when the hardness and toughness are both high; they will be low when either hardness or toughness, or both, are low. These numbers should therefore be in some degree proportional to the durability of the steel. We cannot say that they will be strictly proportional to durability unless we assume that hardness and toughness are the only qualities constituting durability, and that they are equally important factors in durability, but these are assumptions we have no right to make. Either hardness or toughness may be the more important factor, according to the nature of the material the tool is required to cut.

It is an established fact that the steel which is best for cutting hard materials such as tire steel is not necessarily the best for cutting soft materials such as mild steel or brass, and this may be because a harder tool is required for one class of material and a tougher for the other. Nor can we safely assume that hardness and toughness are the only factors in durability. Some steels (notably the tungsten steels) possess a property of resisting abrasion which does not appear to depend directly on hardness or toughness, and can only be measured by an abrasive test—preferably an actual cutting test. It is certain that a tool which is very soft or very brittle will not be durable. It is almost certain that a given tool will gain in durability as it becomes harder and tougher; but it by no means follows that the specimen of steel which carries the heaviest load with the least deflection will make the most durable cutting tool.

Recognizing, then, that the product of hardness and toughness may bear only an approximately proportional relation to durability, let us examine the curves produced by plotting these products on a temperature basis. The curves are shown in Fig. 4, and the durability

* From a paper read before the Iron and Steel Institute, and published in the *Iron Age*.

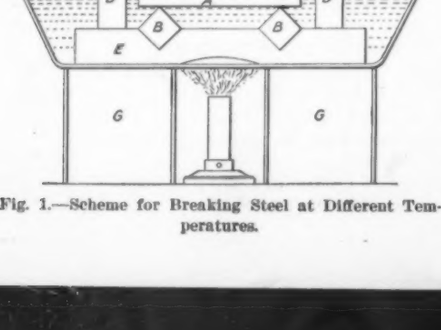



Fig. 1.—Scheme for Breaking Steel at Different Temperatures.

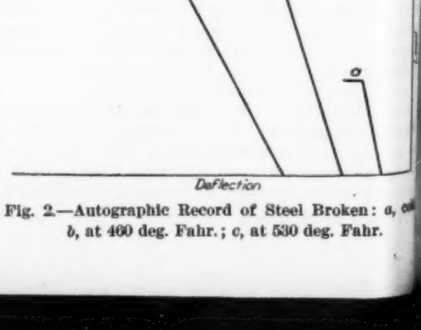



Fig. 2.—Autographic Record of Steel Broken: *a*, cold; *b*, at 460 deg. Fahr.; *c*, at 530 deg. Fahr.

speed curves obtained from specimens of the same steel by actual cutting tests made on the tool steel testing machine are shown in Fig. 5. Two sets of curves are shown in this figure. The full lines represent the durability of tools cutting under water, and the dotted curves are taken from the same tools cutting dry. It is at once apparent that there is a very striking similarity between the curves obtained by breaking (Fig. 4) and those obtained by cutting (Fig. 5). In each case there is a very low durability at low speeds or temperatures, a rise to a high maximum as the speed or temperature increases, and a fall to a low value when the speed or temperature exceeds a certain value.

It is especially noticeable that the range of speeds and temperatures which gives the steel a high durability is a very narrow one. One important difference will be noticed. The breaking tests all show a high durability at atmospheric temperature and a rapid fall to 50 or 100 degrees, but this feature is entirely absent from the curves obtained by cutting. From this it might be surmised that at the lowest cutting speed, viz., 20 feet per minute, the edge of the tool was at 50 to 100 degrees, and that the tools would have a higher durability when cutting at still lower speeds.

Tests were made at speeds as low as 2 feet per minute, and the tool was flooded with a freezing mixture, but the wear was extremely rapid, and no increase of durability was found. There is no doubt a considerable amount of heat generated in cutting a tough steel, no matter how slow the speed, and it may be that the cutting edge was considerably above atmospheric temperature even under the extreme conditions mentioned. This point, however, requires further investigation.

### TEST OF HIGH-SPEED TOOLS.

Breaking tests were made with high-speed steels of two well-known brands. The specimens, 3 × ½ × ¼-inch, were hardened by being preheated for 2½ minutes at 850 degrees, then heated for 50 seconds at 1,275 degrees, and quenched in salt bath at 672 degrees for 30 seconds. The breaking tests were carried out in the manner described above, and the resulting hardness and toughness curves are shown in Fig. 6. The durability-temperature curves (Fig. 7) resemble those of the carbon steels (Fig. 4) in showing a marked fall in durability from atmospheric temperature to 50 degrees, this feature being entirely absent in the curves obtained by cutting (Fig. 8).

This effect of temperature on durability is shown in Fig. 9, which represents the speed-durability curves of a high-speed steel tool cutting (1) dry, (2) with lard oil, (3) with water. At the low speeds, 20 and 30 feet per minute, the tool was most durable when cutting dry, and least durable with water. At the highest speeds the position is reversed, while at intermediate speeds the lard oil gave the highest durability. The oil appears to exercise a double function. It acts as a cooling medium and enables the tool to work at much higher speeds than are practicable when cutting dry; but, as a cooling medium, it is inferior to water, and therefore less conducive to durability at very high speeds. It has, however, a lubricating effect which is not possessed by water, and is highly conducive to durability at speeds which do not generate an excessive amount of heat. The oil gives the highest durability, but not at the highest speed.

The curves in Fig. 10 illustrate the extreme importance of the time factor in the hardening of high-speed steel. The dotted curve represents the durability of a high-speed tool which was preheated for 4 minutes at 850 degrees, heated for 1 minute at 1,275 degrees and quenched in salt at 675 deg. Cent. The full curve shows the durability of the same steel preheated for 2½ minutes and heated for 50 seconds at the same temperatures. Evidently the first steel had been injured by too prolonged heating.

The cutting tests have shown in every case that the durability increases when the cutting speed is raised above 20 feet per minute. These cutting tests have also shown that the durability always increases when a tool working at 20 feet per minute is allowed to cut dry instead of with water, or with hot water instead of cold. It is impossible to doubt that these are different manifestations of the same physical change in the steel. A great deal of the metal cutting in every engineer's shop consists in taking fine finishing cuts, often with water on the tool. If such cuts are taken at a slow speed the temperature of the cutting edge may not rise above 100 degrees, in which case the tool will be quickly blunted. Its durability can be increased by increasing the speed or by cutting dry. Many cases are known to have occurred in ordinary workshop practice, where an increase in cutting speed has actually resulted in increased durability of the tool.

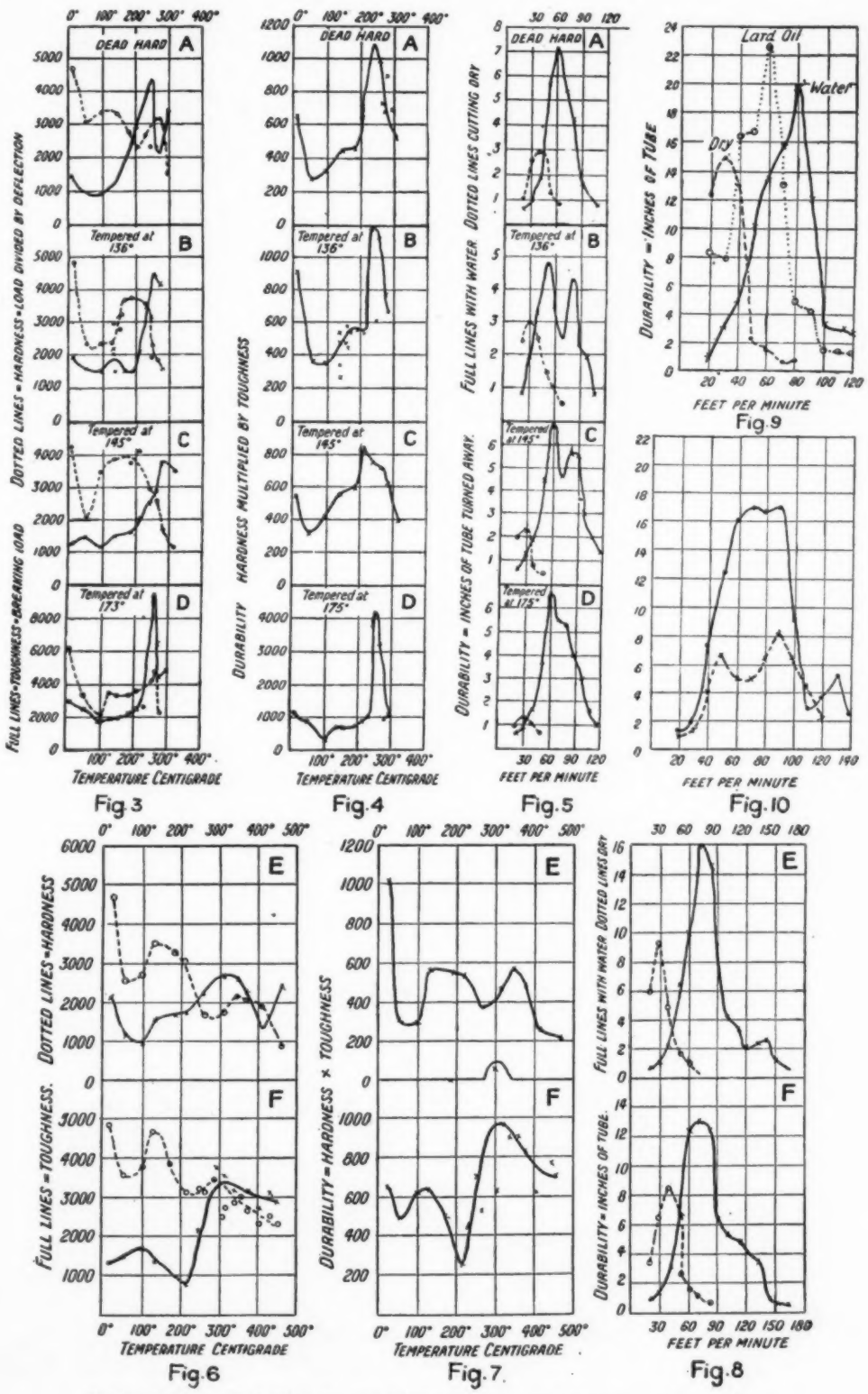
High-speed steel can be so hardened as to retain its durability at fairly low temperatures, and there are now on the market tungsten steels specially adapted for low-temperature work, such as finishing very heavy forgings; but every description of steel known to the writer loses its durability if the cutting temperature is low enough. It should be noted that a low cutting temperature can only occur when there is a combination of low speed with light cut. A heavy or moderate cut raises the temperature of the cutting edge above 100 degrees, even at very slow speeds.

The phenomenon of the double-peaked curve is not completely elucidated, though the evidence goes some way to explain it. The variations of hardness and toughness with temperature are of a complicated character, and the cleft between the two peaks of a durability curve appears to be caused by the conjunction of depressions in the hardness and toughness curves at a particular temperature. The relative heights of the two peaks are found to vary with the conditions of cutting, and this variation may be due to a change in the relative importance of the hardness and toughness factors, according to the quality of the material cut or the shape of the tool.

The decline in durability which takes place when a certain limiting speed is exceeded is evidently caused by an actual softening of the cutting edge by the heat generated in cutting. This softening, which is extremely local, takes place even when the tool and the work are practically immersed in running water. The speeds and temperatures at which the softening occurs depend largely on the particular hardening process which has been applied to the tool, and are generally highest in high-speed steel.

It is not yet possible to establish an exact scale of cutting temperatures corresponding to the scale of cutting speeds, but a comparison of the temperature-durability curves obtained by breaking tests with the speed-durability curves obtained by cutting tests, enables us to make an approximation.

To establish a correspondence between the speeds of cutting with and without water, a comparison may be made between the full and dotted curves in Figs. 5 and 8, from which it appears that the effect of using water is approximately to double the cutting speed; in other words, the edge of a tool flooded with water attains about the same temperature as the edge of a tool cutting dry at half the speed. This must not be taken as a general statement applicable to all cutting operations. The dry cutting temperature depends largely on the volume of metal operated upon. The tube used in the tool steel testing machine is small in diameter and light in section;




Cutting Tests of Tool Steel Compared With Hardness and Toughness Determinations.

Figs. 3, 4 and 5 cover tests with carbon steel; Figs. 6, 7 and 8 cover tests with high-speed steel; Fig. 9 shows speed-durability curves of a high-speed steel cutting with and without lubricants; Fig. 10 shows speed-durability curves of the same high-speed steel differently hardened.

it becomes considerably heated under a dry cut. In machining a large forging the body of metal absorbs a great deal of heat, with only a slight rise in temperature, and the use of water has less effect on the cutting speed.

Considerable interest attaches to a comparison of the durabilities of carbon and high-speed steels. It appears from Figs. 5 and 8 that the high-speed steel has two distinct features of superiority. The speeds at which it attains its maximum durability are not very different from those at which carbon steel is most durable, but the high-speed steel is several times at durable at these speeds.

## Engineering Notes

**The Effect of High-pressure Steam on the Crushing Strength of Portland Cement Mortar and Concrete.**—It is a well known fact that the hardening of Portland cement is accelerated by exposure to heat after hydration, but the value of this acceleration and the possibilities of its application to commercial purposes have not been extensively investigated.

In the manufacture of cement products, such as building blocks, architectural stone, drain tile, sewer tile, fence posts, etc., it is highly desirable to produce a material of uniform and known quality. Under present methods of manufacture the product is not of uniform quality. Even under laboratory conditions of manufacturing, storing, and curing a variation of 50 per cent in strength may be obtained between maximum and minimum values for similar concrete, mixed and molded under apparently the same conditions.

At the present time many manufacturing plants find it to be economical and highly desirable to cure their products by exposing them to heat in the form of steam at atmospheric pressure. By this means it is found that the concrete becomes sufficiently hard in the course of several days to permit handling and shipment. The heat accelerates the setting and also aids in the production of a more uniform quality of material.

A series of tests has been made by R. J. Wig of the Bureau of Standards to determine what acceleration in hardening could be obtained by using steam under pressure, with corresponding higher temperatures.

In No. 5 of the Technological Papers, published by the Bureau, Mr. Wig summarizes his conclusions as follows:

The conclusions drawn on tests of this character must be understood as only directly applicable to materials similar to those tested and they must be limited by the limitations of the investigation. However, the test piece was of good size, and considering the large number made and tested, the reliability and accuracy of the results may be accepted.

1. Steam up to 80 pounds per square inch gage pressure has an accelerating action on the hardening of Portland cement mortar and concrete.

2. The compressive strength increases as the steam pressure is increased.

3. The compressive strength increases with the increase in the time of exposure to steam.

4. A compressive strength considerably (in some cases over 100 per cent) in excess of that obtained normally after aging for six months may be obtained in two days by using steam under pressure for curing the mortar.

5. Steam under pressure, if of sufficient duration, permanently accelerates the hardening of the mortar, giving subsequent constant increase in compressive strength with age.

6. The steam-cured mortar or concrete is of much more uniform appearance and much lighter in color than normally aged mortar or concrete made from the same materials.

7. The mortar or concrete should obtain an initial set before it is exposed to the steam treatment.

8. For steam curing a "quaking" or medium consistency is preferable to a very dry or a very wet consistency.

9. The initial modulus of elasticity and the yield point of the mortar increase directly with the duration of steam treatment.

10. The initial modulus of elasticity and the yield point of the mortar increase directly with the steam pressure.

11. The initial modulus of elasticity does not increase in direct proportion to the increase in the ultimate compressive strength of the steam-cured mortar.

12. Results indicate that the compressive strength obtained by steam curing is directly proportioned to the cement content of the mortar.

**Osmiridium,** which is largely used in the manufacture of electric lamps, is found in important quantities in the neighborhood of the Savage River, on the West Coast of Tasmania, not far from the Mount Bischoff tin mines. Official returns state that for the three months ended March 31st, the production of osmiridium in the district named was 409 ounces. The metal finds a ready sale in Germany at about $37.50 an ounce.

## Trade Notes and Formulæ

**Alloy for Making Castings of Coins.**—This alloy, which is of special value to medallists and coin-collectors, must be hard and produce sharp impressions. A metal mixture that answers these requirements consists of the following parts by weight: Tin, 3; lead, 13; and bismuth, 6. Or tin, 6; lead, 8; and bismuth, 14.—*Der Metallarbeiter.*

**German Silver Alloy.**—The alloys known by this name vary greatly in their composition. A good polishable mixture consists of copper, 50 parts; zinc, 25 parts; nickel, 25 parts. According to the various purposes for which they are to be used, the alloys vary in composition as follows: 50 to 60 per cent of copper, 19 to 31 per cent of zinc, 13 to 18 per cent of nickel. A very good pure white alloy, known as "Argazoid Metal," consists of copper, 55 parts; zinc, 23.198 parts; nickel, 13.406 parts; tin, 4.035 parts; and lead, 3.544 parts.—*Der Metallarbeiter.*

**Artificial Ageing (Dulling) of Silver.**—The production of antique silver, as effected by rubbing silver or silvered metal surfaces with graphite, "graphitizing," as it is termed, is a purely mechanical process. The effect of the dust of centuries is reproduced by rubbing in carbon-powder, i. e., graphite or black lead, in a mixture of 6 parts graphite, 1 part bloodstone and oil of turpentine. When the application is dry, the surplus is rubbed off with a soft leather and a soft brush and the high places are polished by rubbing with a linen rag moistened with alcohol.—*Neueste Erfindungen und Erfahrungen.*

**Electrolytic Process for Producing a Dark Metallic Coating on Metals.**—For the production of a black or deep dark blue metal coating, polish the article, treat it afterwards with acid or in a sand blast and expose it in a nickel solution containing a decoction of licorice root, to a current of ordinary tension. After obtaining the deposit, suddenly lower the tension, without removing the article from the bath. As composition for the bath is given, 20 grammes sulphate of nickel, 14 grammes sulphate of sodium, 1 gramme chloride of nickel, 1015 grammes boracic acid in 100 liters and 5 grammes licorice extract. In place of the latter, glucosides or phloroglucosides can be used.—*Der Metallarbeiter.*

**Bright Silvering by Boiling.**—Silver plating by boiling can be effected by the use of fluids resembling in their composition those used for cold silver plating. If, for instance, the metal objects to be silvered are immersed in a fluid consisting of cream of tartar 6 parts, common salt 6 parts, and chloride of silver 1 part, we obtain, after boiling for 15 to 20 minutes, a beautiful and durable coating, which, however, has but little luster. If we desire the coating to be bright, we heat the article, as it comes from the silvering bath, in a solution consisting of 3 parts hyposulphite of soda, 32 parts water, 1 part sugar of lead, water 16 parts. A black sulphide of lead will be precipated from the fluid and after heating from 10 to 15 minutes to 70 to 80 deg. Cent., the object will assume a bright silver polish.—*Deutsche Goldschmiede Zeitung.*

**A Substitute for Celluloid.**—The valuable properties of celluloid are seriously affected in its use for some purposes, by its high degree of inflammability. As a result, a non-combustible substitute for celluloid has long been sought. The French chemists, Bethisy, Fochard and Fignes, have produced such a substance from tetranitrocellulose which contains 40 to 50 per cent of water, from a fluid carbohydrate. The water is removed after the mixing of the mass by pressure and the residue transformed into a plastic mass by the addition of glacial acetic acid, ether, acetone, acetate of amyl and alcohol. After 24 hours it is pressed between heated rolls until it assumes a solid form, after which the cylinders thus produced are cooled and denitrated by suitable means. The rolling is then continued and the sheets obtained are treated in a steam chamber under a hydraulic pressure of 150 atmospheres for about 6 hours. The pressure is now increased to 200 atmospheres and in place of steam it is exposed to the effects of a stream of cold water. Under this treatment the sheets are transformed into blocks of great hardness which are again divided up into sheets or rods and dried. The process given provides also for the production of a collodion-like substance.—*Technische Rundschau.*

**Coloring Gilt Bronze Articles.**—1. Gilded bronze articles can be given various shades of color, says G. Buchner, in *Metallfärbung.* If it is desired to obtain a brilliant orange-yellow color, such as is seen in artists' or shell gold, brush a little less than usual with the scratch brush, heat the article a little more than if it is to remain matt, to ensure a uniform color, allow it to cool off somewhat, apply the artist color (a mixture of oxide of iron, alum and common salt with vinegar to make a rather stiff paste) heat to about 130 deg. Cent. until the color begins to turn black and water splashed on evaporates with a hissing noise; cool in cold water, dip in water slightly acidulated with nitric acid, dry over a gentle coal fire and polish the prominent places. To ensure the greatest uniformity in the distribution of the orange-tinted color the heated article, after being cooled in cold water, is brushed over with a paint brush dipped in vinegar, if its surface is smooth; in the case of relief or engraved articles the brushing should be done with dilute nitric acid. The rationale of this process consists in the fact that the surfaces of the bronze are thereby freed from the oxides resulting from the gilding process, so that the pure gold color comes out. 2. If the article is to have the reddish color of the copper-gold shade, the bronze, after the volatilization of the quicksilver while warm is placed in gilders' wax (consisting of yellow wax mixed with finely powdered verdigris and some burned alum or borax) and then held over a coal fire and heated until the wax is burned off. After the wax has been burned off, the article is dipped in water, rubbed with a scratch-brush, dipped in vinegar or greatly diluted nitric acid, washed off, polished with steel or bloodstone, again washed, dried with a linen cloth and finally dried over a gentle fire. Where the color is unattractive, or uneven, the article is brushed over with a paste of verdigris and water; this is dried over a gentle fire, cooled in water and brushed with the acid liquid.

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